

Ph.D. Dissertation – Chungah Kim; McMaster University -Health Policy

**SOCIOECONOMIC INEQUALITIES IN SUICIDE AND SUICIDAL
BEHAVIOUR AND ROLES OF SOCIAL POLICY**

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BEHAVIOUR AND ROLES OF SOCIAL POLICY**

A Dissertation Presented

by

Chungah Kim

Submitted to the Graduate School of the
McMaster University in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

March 2021

Health Policy PhD Program

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McMaster University

DOCTOR OF PHILOSOPHY (2021)

TITLE: SOCIOECONOMIC INEQUALITIES IN SUICIDE AND SUICIDAL
BEHAVIOUR AND ROLES OF SOCIAL POLICY

AUTHOR: Chungah Kim, Bachelor of Business Administration (Korea University),
Master of Public Health (Seoul National University)

SUPERVISOR: Dr. James R. Dunn

MEMBERS OF SUPERVISORY COMMITTEE: Dr. Michel Grignon, Dr. Carles
Muntaner, Dr. Marisa Young

NUMBER OF PAGES: xv, 174

Lay Abstract

There is substantial evidence that suicide and suicidal behaviour are disproportionately observed among those with lower socioeconomic positions. Prior literature suggests that policy measures tackling severe socioeconomic deprivation may have impacts on reducing health gaps. However, little research is conducted to examine what effects can be brought by social and welfare policies on suicidal behaviour. This dissertation contains three studies on socioeconomic inequality in suicide and suicidal behaviour and examines the impacts of socioeconomic policies and welfare generosity that may tackle inequality. The overarching aim of the dissertation is to advance our understandings of socioeconomic inequality in suicide and suicidal behaviour by providing a systematic analysis of socioeconomic inequality in suicide and suicidal behaviour and roles of social policy and welfare generosity on suicide and suicide inequality. The dissertation contributes to the literature by mapping the relevant literature, identifying research gaps about socioeconomic inequalities in suicide, and suicidal behaviour and demonstrate novel findings about the roles of social policy.

Abstract

There is substantial evidence that suicidal behaviour is disproportionately observed among those with lower socioeconomic positions. Prior literature suggests that policy measures tackling severe socioeconomic deprivation may have impacts on decreasing the health gaps. Yet, little research has been conducted to examine the effects of social and welfare policies on suicidal behaviour and its inequality. This is in part because the understanding of the socioeconomic inequity in suicidal behaviour has been limited by the strong biological individualism, thereby overlooking the potential importance of social and welfare policies to tackle the population-level determinants of suicide. Using jurisdictional and temporal variations in social policies and patterns of suicide, this dissertation contributes to the literature by providing a summary of the current knowledge base of socioeconomic inequality in suicide and suicidal behaviour, identifying the knowledge gaps and future research questions, and adding novel evidence on the impacts of individual social policy and aggregate welfare generosity on suicide mortality and its inequality. In Chapter Two, consists of a scoping review of studies addressing socioeconomic inequalities in suicide and suicidal behaviour or the relationship between socioeconomic positions and different outcomes of suicidal behaviour in high-income countries with quality data. The literature is summarized to map the findings on the socioeconomic inequity in suicidal behaviour. The chapter concludes with an assessment of gaps in the current knowledge base and suggests a future research agenda. In Chapter Three, I examined whether relative

welfare generosity in Canadian provinces is associated with overall suicide mortality and employment-based inequalities in suicide mortality by exploiting the provincial differences within Canada. In Chapter Four, I investigated the effects of two recent social pension reforms targeting older adults—Basic Old Age Pension (BOAP) and Basic Pension (BP)—implemented in South Korea on suicide mortality. Taken together, the findings of the dissertation contribute to the existing literature by mapping the relevant literature, identifying research gaps about socioeconomic inequalities in suicide, and suicidal behaviour, and examining the roles of social policy as a moderator of socioeconomic inequalities in suicide.

Dedicated to my beloved grandmother
R.I.P. 늘 보고 싶은 할머니

ACKNOWLEDGMENTS

One of the people I love the most in my life is my grandmother. She was born in 1924 and lived during a turbulent time in (modern) Korean history. She lost her husband three months after the Korean War began. He was killed by communist guerrillas from North Korea. When he was killed, she had a son who was three days old. She brought up my sister and I when my parents had to leave their hometown to earn money because of financial problems. I watched my grandmother lose many people around her. My cousin died of a tumor at the age of five, and many people—her friends and neighbors—passed away before her. However, the most lamentable moment in my memory was when my grandmother's younger brother died of suicide. It is impossible to describe her sadness and sobbing into words or expressions with any words existing in this world. This helped lead the way for me to become a passionate researcher. It has been almost 10 years since I started to study suicide. I still think that among all the health inequality issues, the area where injustice and tragedy are still poorly understood is suicide.

I had help from numerous people before this dissertation came out. First of all, I would like to thank Dr. James R. Dunn, my advisor. Without his generosity, understanding, knowledge and support, this dissertation would not have come to the world. I would also like to thank three professors in the dissertation committee: Dr. Carles Muntaner, Dr. Marisa Young, and Dr. Michel Grignon. Their expertise, knowledge, and encouragement helped to further improve the completeness of the dissertation.

Thanks to my friends, peers, staff, and colleagues at McMaster: to Donya, Fanor, Gum-Ryeong, Junghwa, Kibria, Lydia, Lindsay, and Robbie and all other friends in the health

policy program and colleagues at the CRUNCH. I also want to thank my friend Deban, for her help proofreading this thesis.

To my family members (my parents, my little sister, and my parents in law) — You all kept me grounded throughout this journey.

Finally, to my best friend and life-time partner, Duckkun, you stand by me when I'm happy, sad, miserable, and honored. I believe life is worth living as long as I am with you. I truly appreciate your being with me always.

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LIST OF ABBREVIATIONS

AME	Average Marginal Effect
BOAP	Basic Old-Age Pension
BP	Basic Pension
CanCHEC	Canadian Census Health and Environment Cohort
CANSIM	Canadian Socio-economic Information Management System
CI	Confidence Intervals
CITS	Controlled Interrupted Time-Series
DID	Difference-In-Differences
GDP	Gross Domestic Product
HiAP	Health in All Policies
HIC	High-income country
HR	Hazard Ratio
ICD	International Classification of Diseases
IRR	Incidence Rate Ratio
LMIC	Low- and middle-income country
MDIS	Micro Data Integrated Service
OECD	Organization for Economic Co-operation and Development
OR	Odds Ratio
RR	Relative Risk
UD	Undermined death
UK	United Kingdom
US	United States
SEI	Socioeconomic inequality
SEP	Socioeconomic positions

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CHAPTER 1

INTRODUCTION

Background and Rationale

Suicide is a tragedy. It is a tragedy not only for the deceased, but also for families, and friends they leave behind and the society where they belong to. Studies have shown that suicide also has lasting effects that include potential suicides, as well as feelings of remorse, grief reactions and mental disorders¹. From the public health perspective, approximately 800,000 people die by suicide every year and it remains the second most common cause of death in those aged 15-29, fifth in aged 30-49 and the fifteenth in all age groups across the world².

Similar to many other health outcomes, suicidal behaviour and mortality are overrepresented by those with lower socioeconomic positions (SEP)—for example, the unemployed, especially the long-term unemployed, those with lower educational levels, those experiencing poverty, homelessness, and eviction³. In fact, suicide is a cause of death that shows a relatively strong socioeconomic gradient in many countries, even though there are considerable variations in terms of both overall levels of mortality and inequalities. For example, a cross-national study of 15 European countries found that the level of relative suicide mortality was moderate compared to other causes of deaths included in the study, showing slightly weaker gradients than deaths from diabetes mellitus and slightly stronger gradients than deaths from road traffic accidents⁴. In Canada and South Korea, the two countries covered by empirical studies of this dissertation, socioeconomic inequalities (SEI) in suicide mortality are at relatively higher levels of cause-specific mortality rates^{5,6}. Relative inequalities were stronger than deaths

from general infectious and parasitic diseases and slightly weaker than deaths from tuberculosis in South Korea while being stronger than deaths from respiratory diseases and weaker than cervix uteri cancer in Canada^{7,8}.

Nevertheless, the issue of inequity in suicide and suicidal behaviour has not received the recognition that it deserves. In 2011, Platt indicated that no country other than New Zealand had clearly identified a reduction in suicide inequalities as a primary goal of the national suicide prevention strategy.⁹ However, despite the implications of his paper, there has been little to no change in the recognition of suicide related risk factors¹⁰. For example, the American Association for Suicidology still does not list socioeconomic deprivation as a relevant risk factor¹¹. This negligence is appalling, given that so-called “deaths of despair¹²”—deaths from suicide, drugs, and alcohol dramatically increased among those with a high school education or less, and accounted for the shocking fall of life expectancy for the general population in the United States (US) from 2014-2017¹³. In addition to the surge of suicides among those with lower SEP, the late 2010s saw the divide between low- and high-income earners reached historically high records since the Great Depression, and attempts to systematically understand SEIs in suicide and deal with it have not been observed in the US^{14,15}.

The situation is not much different in other High-Income Countries (HICs). A recent cross-national study reported that educational inequalities in suicide has been widening over the last two decades in fifteen European countries, compared to SEI in suicide mortality in the 1990s, despite the general decreasing trends in overall suicide mortality¹⁶. Evidence from Australia¹⁷, Japan¹⁸, and South Korea⁶ also indicates that SEIs in suicide mortality have been increasing (or at least have increased until recent years). However,

much like the US, none of the above mentioned countries have reflected the equity lens in their national suicide prevention strategies.

Meanwhile, SEI in suicide and suicidal behaviour is also a severe problem in low- and middle-income countries (LMICs). Infact, LMICs account for about 75% of globally occurring suicides¹⁹ illustrating the impact of SEI on suicide on a global scale. Of course, in LMICs, suicide deaths are disproportionately represented by those with lower SEP²⁰. Nevertheless, not only do LMICs have few resources to deal with the burden, but there is also little evidence on the associations between SEP and suicide and suicidal behaviour.

The absence of policy efforts to tackle the inequity in suicidal behaviour may be attributable to insufficient synthesized knowledge. Although many studies have been conducted on the associations between SEP and suicide/suicidal behaviour for over two decades now, we still lack synthesized knowledge that covers the relationship between SEP and suicide and what other factors involved the relationship. Thus, this dissertation will provide a systematic analysis of the relationships between SEP and suicidal behaviour. This is followed by an examination of the roles social policy and welfare generosity play on suicide and the inequality in suicide. This dissertation will enhance the prevailing knowledge and understanding of SEI in suicidal behaviour.

Aims of the Dissertation

The overarching purpose of the dissertation is **to advance our understanding of socioeconomic inequality in suicide and suicidal behaviour by providing a systematic analysis of socioeconomic inequality in suicide and suicidal behaviour and roles of social policy and welfare generosity on suicide and suicide inequality.**

The first study in this dissertation summarizes studies relevant to the unequal pattern of suicidal behaviour to examine the knowledge base and identify research gaps that should be prioritized. The second study in the dissertation examines temporal and jurisdictional variations in social policy in suicide mortality in Canada, while the third study examines the impact of an income supplement program for older adults in South Korea on suicide mortality.

The specific aims of each study are

Objective 1: to investigate what we know about SEI in suicidal behaviour and identify the knowledge gaps and thus provide future research suggestion

Social determinants of suicide have long been addressed and the associations between SEP and health have been well established²¹. However, despite the existing literature reviews that have summarized the available evidence on social deprivation and suicidal behaviour, there has not been a thorough synthesis of the knowledge base with a specific focus on SEI in suicidal behaviour and factors that may affect SEI or the associations between SEP and suicide. Little is known about the extent to which SEI in suicidal behaviour exists in general and by sub-population, and the factors related to SEI in suicidal behaviour.

In my first study, I aim to enhance our understanding of the current scope of research over SEI in suicidal behaviour and guide future research by conducting a comprehensive scoping review. The specific aims of the study were: (1) to analyze the degree of SEI in suicidal behaviour, (2) to shape the map of the current knowledge about the relationship between SEP and suicidal behaviour and factors that moderate the relationship, and (3) to find the research gaps and outline future research suggestions on the issue.

Objective 2: to examine the roles of welfare generosity on suicide and employment-based inequalities in suicide in Canada

Previous research finds that welfare generosity may have salutary impacts on suicide mortality or moderating impacts between unemployment and suicide. However, existing studies in this area have depended on single-level time-series studies (mostly aggregate models—i.e., ecological level), making it hard to infer the association at the individual level. Moreover, so far, no study has investigated whether sub-national variations in welfare generosity are associated with different levels of suicide mortality in Canada.

The second study estimates the effects of welfare generosity across Canadian provinces on suicide mortality and employment-based inequality in suicide after adjusting for the compositional effects (individual-level covariates). Multi-level analyses are to deal with the limitations of single-level studies. The specific aims of the study are: 1) examine whether the generosity of provinces' social policies is associated with overall suicide mortality and 2) test whether welfare generosity can moderate the association between labour market marginalisation and suicide in Canada.

Objective 3: to evaluate the effects of two social pension reforms on suicide mortality in South Korea

In very recent years, a growing body of research has been exploiting exogenous variations in social policy changes, including changes in the level of benefits, to investigate the impacts of social and welfare policies on suicide^{22–25}. Recent literature has specifically tested the effects of interventions targeting working-age populations, such as increasing the minimum wage²⁶, income-tax credits^{22,27}, and unemployment benefits²⁴. Otherwise, there have been studies of cash transfer programs aiming at the overall population on suicide, but not in specific sub-populations. Literature examining the role of income security programs for older populations on suicide in the population is also lacking.

In the third study of the dissertation, I evaluate the impacts of two major social pension reforms in South Korea. The two reforms significantly extended the beneficiaries of the social pension and doubled the amount of cash benefits for older populations. Adopting controlled-interrupted time-series analyses—a powerful quasi-experimental design, the chapter aims to examine whether income security programs targeting at older adults are associated with reductions in suicide mortality.

Dissertation Overview

The dissertation consists of three studies on the impact of socioeconomic factors and suicidal behaviours, including the impact of social policies. The three chapters are formatted as independent articles for publication in peer-reviewed journals in health social policy. They consist of their own abstract, introduction, methods, results, and discussion sections, followed by accompanying references.

In Chapter 2 (study 1), I conduct a comprehensive scoping review on studies addressing SEI in suicidal behaviour with high-quality data in HICs. Chapter 3 (study 2) examines whether provincial welfare generosity in Canada has associations with overall levels of suicide mortality and employment-based inequalities in suicide mortality. Chapter 4 (study 3) estimates the policy effect of two pension reforms targeting at older adults with lower income on elderly suicide mortality in South Korea. Lastly, in Chapter 5, I summarize findings across all the three studies, highlight the contributions and limitations of the dissertation, describe implications for social and health policy, and demonstrate the overall conclusions.

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CHAPTER 2

STUDY 1: SOCIOECONOMIC INEQUALITIES IN SUICIDE AND SUICIDAL BEHAVIOUR: A SCOPING REVIEW

Abstract

Social determinants of suicide have long been addressed and the link between socioeconomic positions (SEP) and health has been well established. However, although there were some reviews to summarize available evidence on social deprivation and suicidal behaviour, synthesis of a broader and updated knowledge with a specific focus on socioeconomic inequalities (SEI) in suicidal behaviour and factors that may affect inequalities have been scarce so far. The present review aims to enhance our understanding of the current scope of research over SEI in suicidal behaviour and guide the future research.

We conducted a scoping review on the relationship between multiple SEP measures and different outcomes of suicidal behaviour in high-income countries with quality data, published in English between 1980 and February 2018. Six databases were used for searching (from January 2018 to April 2018): MEDLINE, Social Sciences Abstracts, Embase, PsychINFO, EconLit, Sociological Abstracts, Applied Social Science Index and Abstracts (ASSIA) with keywords related to SEI in suicidal behaviour. A total of 96 studies met inclusion criteria and were analysed. The study found that the association between adulthood SEP and suicidal behaviour was universally observed in high-income countries and education is most used as a SEP measure, but employment status shows more consistent associations with suicidal behaviour for men and women, and both. We addressed some common topics: (1) key covariates of SEI in suicidal behaviour; (2)

repeatedly measured SEI in suicidal behaviour over time; (3) divergent pattern for suicide mortality by outcome types; (4) life course, childhood adversity, and social mobility; and (5) contextual effects: moderators of SEI in suicidal behaviour. Further research addressing the determinants of SEI and filling research gaps in SEI and suicidal behaviour would help policy makers to establish effective intervention strategies.

Introduction

Despite the persistent association between socioeconomic position and suicidal behaviour, few attempts have been made to delve into the full range of issues involved in socioeconomic inequity in suicidal behaviour. Moreover, the few systematic reviews that have addressed the topic have all focused on narrow research questions leaving gaps in the understanding of the unique characteristics of inequity in suicidology. The present study provides a synthesis of a broad range of high-quality empirical studies of socioeconomic inequalities in suicidal behaviour in high-income countries at both the individual and aggregate levels. In so doing, we hope to deepen our understanding of the current state of the topic and to guide the direction of future research.

Key Concepts: Socioeconomic inequality (SEI) and Socioeconomic Position (SEP)

Socioeconomic inequality (SEI) in suicidal behaviour be defined as “differences, variations, and disparities¹” in suicidal behaviour (defined as suicidal ideation, plans, attempts, and completed suicides²) across individuals and groups. Individuals and groups are not uniform, but vary according to **socioeconomic position (SEP)**, which refers to “the social and economic factors that influence what positions individuals or groups hold within the structure of society³” Although there are many similar terms used interchangeably with SEP, such as socioeconomic status and social class^{4,5}, we use the term SEP for pragmatic reasons, given that most of the studies included in this review did not explicitly clarify the conceptual and theoretical underpinnings of their measures. The term SEP has the additional virtue of encompassing both social stratification and social class⁴. Even though other social relations, mainly gender, race, and ethnicity, are conventionally conceptualized as distinct from SEP, they are nevertheless deeply

intertwined with SEP⁶. Therefore, we include studies that examine these social relations alongside SEP in order to delve carefully into the interaction between SEP, these other social relations, and suicidal behaviour.

Backgrounds and Rationales for Study

One of the most well-known and consistent patterns in psychiatric epidemiology is that suicidal behaviour is overrepresented among people of lower SEP. Despite previous studies' reporting this persistent association, the existence of SEI in suicidal behaviour surprisingly has not, surprisingly, not received much attention in the literature or the policy realms⁷. For instance, a recent comprehensive review synthesizing the evidence for risk factors at multiple levels on the complex processes of suicidal behaviour conflated economic turmoil, rapid changes in social values, and social isolation with the same mechanism of lack of social cohesion as population-level risk factors². This gap was replicated in a review by the American Association for Suicidology and World Health Organization, which omitted low SEP as a risk factor^{8,9}. Without an adequate synthesis of the knowledge base, it is unlikely that policy efforts to diminish the inequity in suicidal behaviour will be made and those that are made may not be successful. Almost no nation-wide prevention strategy sensitive to inequity in suicide has been established in any country: so far, only New Zealand has included the explicit goal of reducing socioeconomic inequity of suicide as a primary purpose of the national suicide prevention strategy⁷.

This surprising apathy is in part attributable to the deep-rooted 'biomedical individualism' in psychiatry and clinical medicine, a phenomenon noted by Geoffrey Rose, who observed psychiatry as a classic example field of prevalent "individual centred

approach^{10,11}”. This is an approach which assumes that population risk is merely the sum of individual risks (identified as the “individual-level fallacy¹²”). Through this lens, medical interventions that address biological risk factors at the individual level are paramount, while interventions that tackle with social determinants are secondary at best^{10,13}. This strong ethos of biological individualism obviates the need for an explanation of, or solution for, the unequal distribution of suicidal behaviour across different socioeconomic groups because the outcome is simply the accumulated results of individual attributes¹⁴. In addition to biomedical individualism, another possible reason for the lack of attention to the inequities in suicidal behaviour is methodological challenges. Suicidal deaths are rare among the general population. Only a few countries have produced data linking individual-level SEP to mortality which yield enough statistical power, due to the low incidence of suicide. Other types of suicidal behaviour, such as suicide ideation and attempts, are more common in the general population, but they are more vulnerable to measurement errors and biases since they often rely on self-assessment and self-report. Moreover, previous studies have demonstrated that the prevalence and incidence of suicidal ideation and suicide attempts show different patterns in the population than suicide deaths.

In recent decades, however, this oversight has begun to change. There are three plausible reasons for this development: 1) the acute changes in suicide rates in certain nations which experienced rapid social transformation over this period, 2) the emergence in the late 1990s of the field of social epidemiology, which focuses on socio-economic variation in a wide range of health outcomes and 3) more frequent uses in administrative data. The radical socioeconomic transformation which certain countries have

experienced, such as drastic collapses of former socialist economies and the 2008 financial crisis, has led to rapid rises in suicide rates in these societies during short time spans^{15,16}. However, because the explanatory models and theories of psychiatric epidemiology could not fit dramatic fluctuations in suicide mortality into a short time span, the approach of analyzing suicide at the population-level and using socioeconomic determinants to account for the phenomenon became more powerful¹⁷, even though the issues of stratification and inequity in the field have not yet been addressed properly¹⁸. Social epidemiology, which had just begun to emerge during the late 1990s, has also accelerated research into the social determinants of a variety of health outcomes, including suicide. The results of a brief search for articles with “suicide & (socioeconomic or social)” in the title or abstract for the years 1980-2018 demonstrate the impact of these two factors: on average, there were 33 such articles published per year during the 1980s. This rate increased to 93 per year in the 1990s, to 146 per year between 2000 to 2008, and to 324 per year since 2009 (Figure 2.1). In addition to these contextual factors, an increase in the availability of large amounts of high-quality data established for administrative purposes, such as national health service registries and vital statistics linked to population censuses and social surveys, has made it possible to tackle questions which would otherwise present methodological obstacles.

Accordingly, some reviews which address SEI in suicidal behaviour have been published, yet they have several limitations. Most of these reviews addressed lower SEP only as part of broader social determinants of suicidal behaviour without distinguishing it from other non-psychiatric social factors conceptualized according to different theoretical underpinnings, such as living arrangements or religious beliefs. They did not take the

inequity issue as an independent focus of research. To the best of our knowledge, there have been only three reviews with a specific focus on inequity in suicidal behaviour. One¹⁹ of them investigated the effects of area-level socioeconomic deprivations on suicidal behaviour to find area effects independent of individual characteristics by summarizing mostly ecological studies. Compositional effects cannot, however, be separated from contextual effects unless multilevel designs are applied¹². Moreover, it is impossible to consider key covariates such as living arrangements and mental health status at the aggregate level.

The other two studies examining SEI in suicidal behaviour did so at the individual level. Li et al., for example, conducted a meta-systematic review examining the association between SEP indicators and suicide mortality with high-quality data and found that the population attributable risk of lower education for suicide mortality is almost equivalent to that of mental disorders²⁰. However, to meet the criteria of a meta-analysis, this review not only restricted the scope to studies with only the outcome of suicide deaths, but also excluded many studies that either had heterogeneous designs or were not stratified by gender, resulting in the omission of seminal studies. Moreover, since it was published in 2009, it could not include more recently published studies with high quality due to recent progress in data collection and an increased interest in suicide as a public health burden after the 2008 recession. The other review²¹, which covered studies done only in middle- and low-income countries, has limitations that are mostly due to data quality in the studies included. The study was also unable to explore other research questions related to SEI in suicidal behaviour, despite the novelty of findings from low- and middle-income countries.

Recognizing the gaps present in previous reviews, we aim with this review to complement earlier work and to present the current state of research on SEI in suicidal behaviour. Out of many different types of review, we chose to do a scoping review out so that a variety of studies with heterogeneous research designs, questions, and methods could be included. The specific purposes of the review are: 1) to examine the extent of SEI in suicidal behaviour, ranging from suicidal ideation all the way to suicide attempts and deaths (following the definition of the concepts of suicidal behaviour outlined in the relevant literature²), 2) to map the research articles and synthesize their findings about SEI in suicidal behaviour as it relates to factors that moderate the inequities, and 3) to identify the gaps in our knowledge and outline a research agenda which will fill them.

Methods

A scoping review was conducted according to the methodological framework of Arksey and O'Malley, which we believe was more suitable for our research questions than a systematic review²². We aggregated the results from each study to synthesize knowledge across different topics although we did not conduct meta-analysis to show what is consistent and what needs further research. A protocol for systematic search and established inclusion and exclusion criteria was developed in advance. (Figure 2.2).

Identifying relevant studies

Six databases were used for searching: MEDLINE, Social Sciences Abstracts, Embase, PsychINFO, EconLit, Sociological Abstracts, Applied Social Science Index and Abstracts (ASSIA). We searched the databases between January 2018 and April 2018 for studies published by January 2018. The databases were searched on the article titles and abstracts with the combination of key words related to outcome and predictors: outcome keywords: suicide, suicidal and predictor keywords: social class, class, socioeconomic position, socioeconomic status, occupation, income, education, employment status, labour market, housing, unemployment, job class. The initial database searches produced 6983 articles after eliminating duplicates and ones written in languages other than English.

Study selection

From the 6983 articles initially identified, 6111 articles were excluded via title and if needed, abstract screening. Of the remaining 872 studies eligible for full-text review, we excluded 783 studies for following reasons: the article was not examining the association between SEP measures and suicidal behaviours (n=202); the unit of analysis was

aggregate (n=211); studies were done in low and middle income countries (n=47); age and gender were not properly adjusted (n=34); SEI was not explored (e.g. examining only those with the low SEP) (n=121); psychological autopsy studies and cross-sectional designs for suicide deaths were adopted (n=38); occupational characteristics were the main focus (n=35); qualitative studies were conducted (n=18); clinical- or hospital-based studies (n=47); only descriptive statistics were given (n=21); and the data was duplicate and the result is similar (n=9). In addition to studies identified through databases, 7 studies were added from hand-searching the reference lists in the included studies. In total, 96 studies were included for the review. Figure 2.2. shows the data selection process.

Charting data

We initially extracted relevant information according to : (1) names of authors, publication year and country of data collection; (2) study aims; (3) gender of participants; (4) suicide outcomes; (5) age ranges and follow-up years of participants; (6) study design; (7) SEP measure; (8) unadjusted odds ratio (OR)/relative risk (RR); (9) adjusted OR/RR (10) whether to include key covariates; (11) whether studies adopted life-course perspectives; (12) whether studies additionally addressed contextual factors; and (13) whether inequalities were repeatedly measured. Extracted information is available in the Table 2.2. No meta-analysis was done because of the heterogeneity in the research questions and covariates.

Results

General characteristics of included studies

Studies examining the association between SEP and suicidal behaviour began to be published beginning with greater and greater frequency starting around the year 2000 (see Table 1). More detailed summaries of the studies are available in Table 2.2. Up to the year 1999, there were only 7 such studies published. Between 2000 and 2008, 34 studies were published, and, between 2009 and March 2018, 55 studies were published. As described above, studies on SEI in suicidal behaviour were pursued with a new vigour with the emergence of social epidemiology at the beginning of the 2000s and the occurrence of the economic recession in 2008.

The most common designs adopted by the included studies were cohort or longitudinal study designs (58.9%), followed by nested case-control or case-control designs (22.1%). The only studies that used cross-sectional designs focused on suicidal ideation or attempts (12.6%). Almost half of the studies (45.3%) were done in Nordic countries (Denmark, Finland, Iceland, Norway, Sweden), where they took advantage of registry data, which shows the importance of the availability of large administrative datasets for longitudinal studies investigating rare events like suicide. About 12% of the studies were conducted in South Korea, which reflects the sharp increase in suicide and suicide inequality after the financial crisis in the late 1990s across Asian countries. Two the articles described cross-national studies conducted in Europe.

The most examined outcome (not mutually exclusive) was suicide deaths (n=69), followed by suicide attempts (n=24) and ideation (n=17). Less commonly studied were suicide plans and suggestions. Gender-stratified analyses were conducted in 44/96 studies and 41/96 controlled for gender in analyses. In 9/96 studies, only men's suicidal behaviour was examined. Only 2/96 studies focused only on women. Of the SEP measures used, educational attainment was the most frequently used indicator, followed by employment status. Occupation-based social class was the least often used. Some studies used other SEP measures, namely: parental occupation-based social class, parental educational attainment, welfare receipt, housing ownership or housing conditions, eviction, car ownership, food insufficiency, financial strain, and SEP composite measures of income and occupation.

Results by SEP measures and types of suicidal behaviour

The association between SEP measures and suicidal behaviour was summarized in Table 2.3. The strengths of association were presented in unadjusted values (adjusted for age and gender). When multiple SEP measures were modelled in a study, we listed them all. The results are presented by gender, given that patterns of suicidal behaviour and inequalities vary substantially by gender. Gender differences in the results will be addressed in detail later.

For the outcome of suicide deaths, about 94% of studies (65/69) reported that at least a lower SEP measure was correlated with increased suicide risks. The 4 studies^{23–26} that reported no association had either a small sample size or even reverse associations. The most consistent association with suicide mortality was found for unstable employment status (51/54 studies) and occupation or social class (12/13 studies), while education

(39/56 studies) and other SEP measures (22/35 studies) showed the least consistent associations. While other SEP measures representing extreme deprivation, such as food insufficiency, home eviction, or social assistance receipts also showed robust relationships, certain indicators such as parental SEPs, did little to predict suicide at all; some even had reverse associations with suicide mortality.

The findings for suicide attempts and ideation were more consistent. For suicide attempts, all of the studies reported that at least one lower SEP increased the risk, even though the associations were less pronounced for educational attainment (9/12 studies) and other SEP measures (11/13 studies) than for income (12/13 studies), occupation-based social class (5/6 studies) and employment status (13/14 studies). As was the case for suicidal ideation, all studies showed positive associations for at least one SEP measure. The associations were most pronounced with income (9/9 studies) in suicide ideation. As opposed to mortality, reverse associations were not shown in either suicide attempts or ideation.

Research themes

Each of the published articles examined in the review was assigned to 1 or more of 6 research themes. All the themes are relevant to SEI in suicidal behaviour or to the association between SEP and suicidal behaviour. Table 2.1 lists what studies are included in each theme.

1. Key covariates of SEI in suicidal behaviour

- 1.1. Other types of social relations: gender, race, ethnicity, aboriginality, and immigration status

These other types of social relations are not considered SEP^{1,5,27}, but the relevant literature has suggested that it is necessary to examine the impacts of SEP across these factors since the effects of social status on health outcomes are often mediated or moderated by SEPs on health outcomes in several pathways²⁷. Firstly, systematic discrimination against racial minorities, women, foreigners, and immigrants may reduce their social mobility, which affects health outcomes, either directly or indirectly, via lower SEP²⁸. Secondly, the effects of lower SEP on suicide risks are contingent on these other social categories. As previous studies have indicated, the adverse effects of lower SEP on ill-health may be moderated among women, some racial minorities, immigrants, and non-aboriginal population, which means that the effects can be greater or lesser depending on other social relations²⁹. Thirdly, suicide acceptability differs considerably among social groups that share different cultures, values and norms, which results in systematically providing protective factors for minority groups with lower levels of suicide acceptability (e.g., African Americans, those with a religious network)^{30,31}. Lastly, coping strategies in faces of life crises, such as being laid-off or suffering from debt, varies across social groups³². This can bring about a significant moderation of SEI in suicidal behaviour.

Of the 56/96 studies that performed an analysis stratified by gender or focused only on one gender, only 11/96 (5/56 gender stratified studies and 6/40 non-gender stratified studies) statistically tested whether there existed a significant gender difference and 6/11 confirmed the interaction. This suggests that most of the studies did not provide the rationale for gender differences. Nevertheless, regular patterns from the results can be observed. In general, the gender differences in SEI are greater not in suicide ideation and

attempts, but rather in suicide mortality. The association with suicide mortality was not as consistent in income and educational attainment among women as it was among men. Of the 20 studies examining the association between education and suicide deaths among women, 8 showed no association and 2 showed reverse associations. As for income, 4/13 studies reported no associations. By contrast, employment status had robust associations with suicide mortality among both men (22/23 studies) and women (19/20 studies). In addition, studies reported that SEI in suicide mortality measured by adulthood SEP was reported more among men than women, while the reverse associations with parental SEP was more clearly shown among women.

Race was included as an independent variable in 11 studies (Table 2.2), all of which were conducted in the United States. One of these studies conducted a stratified analysis by race³³ and two tested whether there were interactions between SEP measures and race on suicidal behaviour^{33,34}. The remaining studies simply adjusted for race without reporting the effect sizes. In a race-stratified analyses, Kung et al.³³ showed that all SEP measures in the model had positive associations with suicide death only among White-Americans, and not among African-Americans. McMillan et al.³⁴ also found an interaction between income and race: more suicide ideation was reported among the non-Hispanic white population than among Asian, Hispanic, Black, and other Americans. Despite the possibility that lower SEP may be a mediator of racial differences, no studies conducted a mediation analysis. The 10 studies that modelled race as a confounder showed that African Americans exhibited low odds of suicidal behaviour, despite the correlation of suicidal behaviour with lower SEP. By comparing models before and after

including SEP measures, 1/9 studies found that introducing SEP measures somewhat accounted for the effects of race³⁵.

Only 3 articles whose models included indigenous status were reviewed; one was conducted in Manitoba, Canada³⁶ and the other two^{37,38} in New Zealand. None of these studies conducted a stratified analysis or investigated interactions, due to the small study size. The Manitoba study, which adopted a case-control design, showed that the risk of suicide attempt is 5.69 times higher among the indigenous population³⁶. One of the New Zealand studies, Collings et al. (2009) reported that, after controlling for covariates, the Maori population is 43% more likely to die by suicide³⁷. This disparity remained the same even after controlling for deprivation at the area level. The other study done in New Zealand simply adjusted for indigenous status and did not report the coefficient³⁸.

Ethnicity, country of birth, and parental citizenship were investigated in 16/96 studies (Table 2.2, Column 10), one of which conducted an analysis stratified by immigration status to compare the sizes of the inequality in SEP between immigrants and non-immigrants. Di Thiene et al.³⁹ showed that inequalities in suicide mortality are smaller among 1st and 2nd generation immigrants than in either the native population or people with mixed immigration backgrounds. Two studies observed how the odds ratio changed by adding SEP measures in models built in a sequential fashion. Of the 2 Studies, Di Thiene et al. reported that risk of suicide mortality decreased among all the generations of immigrant population, compared to native population after adjusting for employment status⁴⁰. In the analysis of Kosidou et al., the introduction of parental SEP into the model increased the risk of suicide attempts among non-European first generation immigrants and reduced the risk among the remaining ethnicities and generations⁴¹. Although both

studies were conducted in Sweden, it is not possible to directly compare the findings of the studies, since Kosidou and colleagues only targeted youth aged 18-29 and suicide attempts while Di Thiene et al. studied people aged 16-50 and suicide deaths. The remainder (13 studies) studies simply controlled for immigration status/ethnicity.

1.2. Living arrangements

Marital status and parenthood, known to be protective factors for suicidal behaviour, are also correlated with SEP in suicidal behaviour, given that marital disruption is closely associated with lower SEP⁴². In the present review, they were one of the most often adjusted factors to obtain the net effects of SEP on suicidal behaviour. 76/96 studies (Table 2.2, Column 10) incorporated either marital status, or parenthood status or both factors in their models. 3/76 provided evidence that the relationship between living arrangements and suicidal behaviour needs to be understood with respect to SEP measures. One of these, Yamauchi et al. examined interaction effects between employment status and marital status by gender in Japan and found that there is a multiplicative interaction between divorce/single marital status and unemployment status for both men and women⁴³. The other 2 studies showed, by comparing models with and without SEP measures, that the protective effects of marital status and parenthood can be, at least in some part, explained by income, education and employment status^{35,44}.

1.3. Mental health status

Mental health status is known to be one of the strongest predictors of suicidal behaviour and also correlated with SEP². Thus, it is necessary to consider what role mental health plays on the relationship between SEP and suicidal behaviour. Most previous research has assumed that ill mental health was a common prior cause of suicide and downward

mobility (i.e., dropout of schooling, loss of income, unemployment). Conversely, some studies have suggested that downward mobility can be a cause of both ill mental health and suicide, assuming ill mental health to be a mediator. It has also been suggested that ill mental health may play a role as a moderator that has varying effects on suicide depending on SEP⁴⁵. Mental health status was included in the models of 39/96 studies (Table 2.2, Column 10). The use of different types of mental health measures is likely to influence the coefficients of mental health and the degree to which mental health moderated the effects of SEP. In this review, 11 of the studies measured mental health by the self-reporting of psychiatric disorder or perceived mental health status, 8 and 6 studies used the psychiatric morbidity and admission history data, respectively, 4 studies ascertained the information from conscription tests, and 7 studies conducted standardized test such as the Center for Epidemiological Study-Depression Scale and the Kessler Psychological Distress Scale. 4 studies used sickness absence records. The studies which ascertained mental health status from more valid measurement methods such as medical records, conscription tests, or registry databases were, with one exception, all done in Scandinavian countries.

Mental health status was treated as a confounder by 38/39 studies, which therefore adjusted for mental health status to isolate the main 5 SEP measures on suicidal behaviour, rather than assuming it to be a mediator. Although we did not summarize or aggregate the results according to by how much the coefficients of SEP changed after adjusting for mental health variables, all figures are listed in Table 2.3. In most studies, incorporating mental health variables in the regression considerably reduced the effect size of SEP measures or, occasionally, even made it insignificant. Rather than assuming

mental health status to be a confounder, one study conducted an analysis stratified by psychiatric hospital admission history to examine the varying effects of SEP for those with or without severe mental disorders⁴⁶. This study examined what effects a change in labour market affiliation brought about on suicide risk by conducting an analysis stratified between the population admitted for a psychiatric disorder and the general population. The study found that the unemployed among the general population without any psychiatric hospital admission history were 1.67 times more likely to die by suicide than the population admitted for a psychiatric disorder. For the population admitted for a psychiatric disorder and discharged recently, suicide risk was lower among the unemployed than among the employed.

2. Repeatedly measured SEI in suicidal behaviour over time

Changes in SEI in suicidal behaviour over time was examined by 13 studies (Table 2.2, column 13), which used repeatedly measured analyses rather than pooled analyses. All of these longitudinally-focused studies addressed only suicide deaths and not other suicidal behaviour, with one exception⁴⁷. Of these 13 studies, 7 focused on examining whether SEI in suicidal behaviour widened during rapid change of macro-economic circumstances. These studies suggest that economic recession with high unemployment rates at a societal level is not necessarily associated with aggravated inequalities in suicidal behaviour or vice versa. It rather depends on the national context. Only one study, conducted in Australia, reported a clear pro-cyclic pattern that, compared to the pre-economic crisis period (2007), the risks of suicide deaths decreased among the employed in 2008 and, conversely, increased among the economically inactive⁴⁸. Another study reported increases in inequalities not during the exact recession period, rather the

post-recession period⁴⁹. Still another study found the counterintuitive result that SEI in suicide mortality declined during the economic recession⁵⁰. The other 3 studies either showed inconsistent patterns in the temporal trends of inequalities during the recession, showing that SEI in suicide mortality began to increase during the recession but deteriorated despite the economic upturn⁴⁷ or found no clear regularities^{51,52}.

The remaining 6 studies in this group explored how SEI in suicidal behaviour changed over long periods (at least 10 years) without a focus on a specific topic. Since the study periods and regional contexts of these studies are heterogeneous, direct comparison is not possible. However, their findings are consistent, in that all included studies found that inequalities in suicide mortality gradually increased overall. Moreover, all studies which examined the 1990s found an increase in that decade. This finding is aligned with the results of a cross-national study that observed changes in SEI in suicide mortalities in 15 European countries over the 1990s, which found in country-stratified analyses that inequalities increased in almost all countries⁵³. A study done in New Zealand, which conducted age-stratified analyses, showed that the gradual increases in SEI in suicide mortality were especially salient among working-age population⁵⁴.

3. Divergent pattern for suicide mortality by outcome types

Some articles in this review conducted multiple analyses on different suicide outcomes that had different strengths or directions of associations with SEP measures. The multiple-outcome studies included in this review can be grouped into 3 categories: studies examining multiple suicidal behaviours along the course of the transition to completed suicide, studies comparing deaths coded as suicide with deaths of

undetermined intent, and studies that compared alcohol-related suicide and non-alcohol related suicide.

Most relevant literature in suicidology has not distinguished the risk factors of suicide mortality from those of other types of suicidal behaviour and has assumed that the same factors predicted all types of suicidal behaviour, even though this assumption has not been substantiated⁵⁵. Therefore, we observed whether suicide ideation, attempts, and death patterned similarly by SEP. Of the 13 studies (Table 2.2, Column 4) that examined multiple suicidal behaviour, the majority, with the exception of 2 studies^{56,57}, showed that SEI in suicidal behaviour is the biggest in death, followed by attempts and then ideation. One study also reported that the general patterns of inequalities over time varied between different outcomes of suicidal behaviour: Kim and colleagues found that SEI in suicide deaths and attempts decreased over time, but that SEI in suicide deaths sharply increased⁴⁷. These findings raise the possibility that suicide deaths may differ from other forms of suicidal behaviour in relation to SEP.

It is controversial whether deaths of undetermined intent should be understood as suicides because many suicides are hidden in them⁵⁸. In fact, previous literature has suggested that one of the criteria for uncovering these hidden suicides is to determine whether the rate of deaths of undetermined intent varies by social class⁵⁹. However, deaths of undetermined intent are so rare that few studies can compare inequalities in them by doing stratified analyses. Of the studies whose outcome is suicide mortality, 27/69 (Table 2.2, Column 4) included both deaths of undetermined intent and suicide, and results of sensitivity analyses found no difference in the impacts of SEP measures with or without deaths of undetermined intent. One study (1/69) that carried out stratified

analyses found that inequality is more pronounced in deaths of undetermined intent than in suicide in Sweden⁴⁹.

Two studies conducted separate analyses for alcohol-related suicide and non-alcohol-related suicide^{44,60}. Both studies were conducted in Finland by the same authors. Given that alcohol abuse and dependence are associated with suicide risk⁶¹ and that problematic alcohol consumption is overrepresented by those with lower SEP⁶², the authors of these studies assumed that there is a steeper socioeconomic gradient in alcohol-related suicide mortality than in non-alcohol-related suicide mortality. Using the same dataset, but published separately by gender, these studies both demonstrated that SEI is larger in alcohol-associated suicide mortality than in non-alcohol associated suicide.

4. Life course, childhood adversity, and social mobility

Recent literature in social epidemiology has focused on SEP in childhood as well as adult SEP to understand the long-lasting effects of socioeconomic disadvantages in childhood on health outcomes in adulthood. It is also important to confirm what kinds of consequences upward and downward mobility lead to in later health. In this review, 20 of the articles (Table 2.2, Column 11) studied the effect of childhood adversity and parental SEP on children's suicide risks from a life course perspective. These articles are divided into two types of studies according to whether adult SEP is considered.

In 5/20 studies, adult SEP was not controlled and only childhood or parental SEP was examined. In 12/20 studies, both were controlled, and 2/20 studies conducted a mobility analysis of suicidal behaviour by comparing possible mobility combinations (e.g., childhood low & adult low SEP compared to childhood high & adult low SEP). Of the 5 studies that did not adjust for adult SEP, 4 found that lower SEP in childhood,

measured as the SEP of either parent, was associated with increased risk to suicidal behaviour including deaths and attempts. Even the remaining study²⁶ reported that individuals with lower parental SEP showed higher odds of suicide, yet the study did not have enough statistical power due to the small number of suicides in the sample.

Meanwhile, in the other 12/20 studies that included adult SEP measures in models, 5 studies found that lower childhood SEP is a risk factor for suicidal behaviour (2 studies for death^{63,64}, a study for ideation⁶⁵ and 2 studies for attempts^{66,67}), even though the effect sizes are low. By contrast, 7 studies which studied suicide deaths (including a study⁶⁸ investigating both attempts and deaths) found that lower childhood SEP is not associated with increased suicidal behaviour. No association was found in 2/7 studies^{24,69} and 4/7 studies^{23,70–72} found a reverse association, showing that lower childhood SEP is protective, after adjusting for adult SEP. The reverse pattern is especially pronounced for women, as shown in all gender-stratified analyses, but the reverse association is weak or not statistically significant for men. 1/7⁶⁸ studies showed a reverse association in suicide attempts, and no association in deaths. Two^{73,74} of these studies, which examined the effects of changes between SEP in childhood and adulthood on suicide ideation and mortality, conducted in Australia and Norway, found that those who experience downward mobility (from high social class to low social class) had the greatest risk of suicide, followed by those whose social class remained low. Overall, lower childhood SEP has an association with increased suicidal behaviour but, once adulthood SEP is considered, the effects of early childhood SEP are mediated by adulthood SEP.

Otherwise, the effects of higher childhood SEP disappear or are even negative, for those experiencing downward mobility.

5. Contextual effects: moderators of SEI in suicidal behaviour

Variations in health outcomes and inequalities across geographical areas have inspired researchers to pay attention to regional effects. 3 types of area effects that link place to suicide were explored among included studies: area-level deprivation, income inequality, and social cohesion (i.e., social capital, social integration, or social network). While area-level deprivation consists of both compositional and contextual factors, income inequality and social cohesion reflect the net effects of area even after controlling for the individual covariates.

Since area-level SEP is often used as a proxy for the SEP of residents of an area, here we introduce studies that examined the impacts of SEP on both suicidal outcomes and inequalities. Although we did not include studies which used only area-level SEP measures, 11 of the studies (Table 2.2, Column 12) we included examined the effects of area-level SEP in addition to individual-level SEP. 8/11 studies conducted regression models with an estimation procedure to deal with clustered data (6 studies with multilevel designs and 2 studies with generalized estimating equations) and a study conducted analyses stratified by level of regional deprivation. 2 studies^{75,76} included area-level SEP measures in the same statistical model without considering clustered effects within geographical areas. Of the studies that adjusted for cluster effects, 6/8 confirmed effects of area-level SEP measures, after controlling for individual-level SEP measures. In the other studies^{77,78}, the statistical significance of area-level SEP disappeared. 2 multilevel studies found a cross-level interaction, which indicates that, in regions and schools where area-level deprivation is higher, those with lower SEP were more protected from suicide mortality^{78,79}. 2 Pooled analyses, not controlling for the clustered effects, found that area-

level deprivation was still significant for increased risks of suicidal ideation and mortality, adjusting for the individual-level SEP measures. By contrast, Burrows and colleagues⁸⁰ found that, in Canadian census tracts stratified by area deprivation, the individual hazard ratio did not show consistent patterns by education and income. To summarize, the results of the studies which looked at the contextual impacts of aggregate deprivation on suicide risk and inequity are very heterogeneous, depending on the outcomes, statistical models and regional contexts.

In the case of income inequality, although two studies tested the association between income inequality and suicide risk (outcome only), they did not focus on inequalities. Their findings were that school- and municipality-level income inequalities^{78,79} did not have direct impacts on suicide mortalities. However, as Liu explained, relative income, measured as the number of people who have an income lower than the individual compared to the total number of people within that reference group, was a mediator of the association between income inequalities across neighborhoods and suicide mortality in Sweden. Finally, despite the existence of studies exploring the effects of social coherence on suicide risks, only Liu tested what effects social cohesion could have on suicide inequalities.

Discussion

Summary of main findings

This exhaustive review of 96 studies has yielded a series of important findings: 1) SEI in suicidal behaviour measured by adulthood SEP exists in almost all included countries, although childhood SEP did not have independent associations with suicidal behaviour after adjusting for adulthood SEP and even had reverse associations among women; 2) education is the most commonly used indicator for measuring SEI in suicidal behaviour, but education was less consistent than other SEP measures, especially for women and in suicide mortality; 3) employment status was the most robust indicator of SEI in suicide mortality out of all SEP measures, while little difference is shown among income, occupation and employment status in suicide ideation and attempts; 4) stratified analyses found that, overall, less pronounced SEI in suicidal behaviour was observed within women, African American, and first-generation immigrants; 5) although many studies controlled for familial status as a critical confounder of SEI in suicidal behaviour, few addressed the complex relationship between the two. There was only feeble evidence that unemployed status had synergistic effects with single/divorced status on suicide mortality; 6) mental health status was assumed to be a confounder in almost all studies and no empirical study was found that conceptualized it as a mediator, although one study found that mental health status may play a role as an effect modifier; 7) the relationship between macro-economic circumstances and SEI in suicidal behaviour is contingent upon the context of each case, but all included studies reported that there was a widening of SEI in suicide mortality in the 1990s; 8) studies examining whether area-level SEP had contextual effects on suicidal behaviour showed inconclusive findings.

Knowledge gaps and future research agenda

Future research in this field should go beyond exploring the simple relationship between SEP and suicidal behaviour. Here, we will provide interpretations of the relevant findings. We will also identify some gaps in what is already known about SEI in suicidal behaviour and make a series of suggestions for future research to enhance the knowledge base and inform policies for reducing SEI in suicidal behaviour.

1. Refining measures of SEP

Almost all studies included in the present review measured SEP implicitly based on a social stratification perspective, as is the case in other social epidemiological research. Although the stratification perspective has gained strong predictive validity, under-representation of relational social class approaches is problematic for several reasons. Firstly, SEI in suicide cannot be fully captured using only the stratification approach. Previous literature has shown that SEI based on stratification and that based on social class can be empirically distinct and represent different aspects of psychopathology^{81,82}. Secondly, the stratification perspective explicitly and implicitly assumes that ‘life chances’ are actively created by human agency, i.e. the ability to obtain enough skills and education for gaining higher incomes and better occupations⁴. This assumption is aligned with the approach of biological individualism, which conceptualizes socioeconomic position as individual attributes^{4,13,14,83}. This likely results in the neglect of the system-level determinants of SEI in suicidal behaviour. Thirdly, the stratification perspective has received criticisms for its lack of inequality-generating mechanisms, in contrast to relational perspectives^{5,14,84}. Future studies should therefore adopt some SEP measures based on the relational approach to address the limitations of the stratification approach.

We also found that employment status is the most consistent measure, and that precarious employment, underemployment, and non-standard employment—different forms of labour market marginalization beyond unemployment—are determinants of suicidal behaviour, even after controlling other SEP indicators. Previous research has also found that precarious employment predicts ill-mental health. To incorporate the emerging understanding of employment status as something more complex than a simple binary of employed vs. unemployed, adopting the relational approach is inevitable, since defining and operationalizing precarious employment requires a relational approach. For example, conceptualizing workers' vulnerability, disempowerment, and the excise of rights all require the adoption of the relational approach^{85–87}. Although all 5 studies that examined the roles of precarious employment used information collected by less rigorous methods (e.g., cross-sectional questionnaire instead of administrative database or census) and investigated “softer outcomes” (e.g., suicide ideation and attempts rather than suicide mortality), this is possibly due to lack of information given the theoretical conceptualization of precarious employment in data drawn from large-scale surveys such as census and registry databases⁸⁶. The growing availability of administrative data and data linkages among different social surveys, along with recent achievements in the definition and operationalization of precarious employment based on theory affords a promising opportunity to utilize these refined SEP measures⁸⁸.

2. Understanding relationships of key covariates and SEP on suicidal behaviour

As the results demonstrated, the key covariates in the topic have been understood in the restrictive way. Most of the included articles understood the covariates as confounders, statistically adjusting for them or doing stratified analyses. Since testing statistical

differences was rarely done for the stratified analyses, we could not confirm whether the differences in results were accidental. Only a few studies examined the effects of covariates as moderators despite the relative ease of doing so. More empirical studies with large sample sizes exploring the possible synergistic relationship between SEP and aboriginality sizes are required, considering that suicide among indigenous communities has been a widespread public health problem in some countries.

Despite the longstanding controversies over understanding mental health status as a confounder or mediator of SEP (equivalent to the “social selection-causation” issue), empirical analyses have been heavily concentrated on testing mental health as a confounder (social selection). The findings of these empirical analyses are aligned with a meta-analytic review of suicide mortality and unemployment⁴⁵. As previous studies have indicated, this practice may underestimate the effects of SEP, as a result of the possible collider stratification bias⁴⁵. Therefore, more varied methods for investigating covariates, including mediation analyses, need to be applied in future research. Further, solution-focused research—examining the effectiveness of possible interventions beyond focusing on the causes of inequalities⁸⁹—should be conducted more often. One such study, which was recently published, found, with time-series data, that the diffusion of SSRI and other anti-depressant drugs was a major source of expanded SEI in suicide mortality in the United States⁸.

3. Distinguishing predictors of SEI in different types of suicidal behaviour

To ascertain or generalize our findings that the magnitude of inequalities was, overall, bigger in attempts and deaths than in ideation and that different temporal patterns are observed in the different outcomes, more studies need to be conducted which compare

SEI in different types of suicidal behaviours in multiple spatiotemporal contexts. Further, if future studies confirm our findings, further work needs to investigate what factors influence the different patterns and sizes of the inequality in different types of suicidal behaviour.

A recently proposed ideation-to-action framework, which suggests that predictors for suicide attempts need to be examined separately from ideations, may provide a crucial clue. In this framework, well-known risk factors for suicidal behaviour—including most mental disorders, hopelessness and even impulsivity—predict suicidal ideation, but do not accurately predict suicide attempts⁹⁰. Meanwhile, particular disorders (such as bipolar disorder, post-traumatic stress disorder, drug dependence/abuse and major depression), access to lethal means of suicide, and connectedness (referring to not only one's connection to other people but one's attachment to any sense of perceived purpose or meaning that keeps one value in living) predict attempted suicides⁹⁰. These predictors are overrepresented among those with lower SEP, which implies that finding the predictors of mortalities and attempts, as distinguished from the predictors of ideations, and prioritizing them for prevention may lead to reducing the inequities. However, no studies to date have been conducted regarding the roles of predictors of suicide attempts on the unequal distribution in suicide attempts and mortalities.

4. Life-course perspective

Although childhood SEP seemed to have effects on adulthood suicide behaviour, these effects were mostly explained by educational and employment paths in adulthood. This finding demonstrates why it is necessary to conduct research from a life-course perspective, employing multiple, dynamic measurements of SEP at multiple stages of

life, rather than measuring a snapshot of a one-time life event. Nevertheless, half of the studies in the review modelled only childhood SEP and most of the remaining half (with the exception of three studies) included a measurement of childhood SEP and one of adulthood SEP. These three exceptional studies used multiple measurements over the life course. They demonstrated that parental SEP did not account for the association between adulthood social class and suicide mortality, but that educational attainment bridging childhood and adulthood as well as indirect effects of employment status had independent effects^{63,70,91}. These longitudinal analyses can also provide useful information for understanding the reciprocal relationships and causal processes between the key covariates and multiple SEPs over the life course. For instance, Studies investigating the mechanisms through which downward social mobility results in great risks to suicidal behaviour can hint about testing the social causation hypothesis given its dynamic nature involving social processes. Lastly, one question that has not been addressed, despite consistent patterns found in multiple contexts, is why the reverse association between childhood SEP and adulthood suicidal behaviour is pronounced among women. Since most of the research using more rigorous methods was done in Scandinavian countries, we cannot confirm whether the findings are generalizable in other contexts. More promising findings may be generated in the coming years by more frequent use of recent advances in linkages of multiple databases which include socioeconomic information, medical records, and mortality, along with a variety of different modelling strategies beyond simply adjusting for previous confounders.

5. Moderating factors affecting SEI in suicidal behaviour

Most studies in this review that either repeatedly measured inequalities over time or measured the variations across geographical regions were confined to simply reporting the strength of different coefficients. There was no research which would explicitly or empirically examine what moderates SEI in suicidal behaviour and only speculative explanations were given. As mentioned earlier, since solution-focused research is related to finding the relevant moderators and intervening in them, future research should focus on finding and testing the relevant moderators. The possible moderators can be divided into two categories: those moderating at the level of individual behaviour and those moderating at the contextual level. As for the former, Mäki and Martikainen⁵² have explained that the inverse association between unemployment at the national level and suicide mortality may be attributable to countercyclical variation in more proximate risk factors, namely alcohol consumption, which means that inequalities between the employed and the unstably employed decreased during recession, probably due to decreased alcohol consumption among only the unstably employed⁵². Although we could not find any research relevant to this question, this explanation could be applied to changing inequalities in other contexts, such as the relationship between increases in opioid use and suicide risk among people with lower SEP in the United States⁹².

Unlike behavioural moderators, contextual moderators are related to more structural factors (i.e. targeting the conditions from which behaviour originates⁹³). For example, the prevalence of high opioid use among those with lower SEP cannot be explained independently of political factors, e.g. lack of access to universal health care and the deregulation of pharmaceutical industries in the United States⁹⁴. Although a behavioural moderator provides proximate mechanisms directly leading to the unequal distribution of

suicidal behaviour, it does not necessarily provide the relevant intervention strategies. As fundamental cause theory has suggested, although direct behavioural cause is eliminated, inequalities persist via different pathways as long as those with higher SEP have more socioeconomic resources to recruit them flexibly to respond to behavioural risk factors. Thus, future research needs to investigate what structural factors can moderate the inequalities. To do so, longitudinal studies measuring changes in the strengths of suicide inequalities and comparative studies should be conducted⁹⁵.

Limitations

Of course, it is not possible to generalize the findings from 96 studies and we may have not identified key literature aligned with our inclusion criteria. Beyond these points, this review has several limitations. We did not apply strict criteria for filtering studies and conducting the quality assessment test. Moreover, we undertook a narrative synthesis instead of a meta-review. Nonetheless, as a scoping review that aims to map the relevant literature on SEI in suicidal behaviour broadly, our study provides rich insight into the inequity issues in suicide research, especially considering that there has been no study that broadly sketches the relevant issues of inequalities in suicidal behaviour, beyond summarizing the effect sizes of SEP on suicide. We cannot draw any causal inference from the findings of associations due to the limitations of the original studies, which were observational. Lastly, although we did not intend to exclude grey literature, the included articles were all published studies, which may mean the review is vulnerable to publication bias towards positive results. Despite these limitations, this scoping review is the first study to map the existing literature on the related issues of suicide inequalities with a focus on inequity rather than sketching all the social determinants of suicide risks.

Conclusion

Research in SEI in suicidal behaviour in high-income countries has begun to expand since the emergence of social epidemiology and the acute social transformation of the economic recession in 2008. The present review demonstrated that the suicide inequalities in high-income countries are a universal phenomenon and that SEPs in adulthood, particularly employment status can predict the association most stably. We also addressed issues related to SEI in suicidal behaviour and what we know and we do not know: understanding the key covariates of the association between SEP and suicidal behaviour, including other social relations, familial status, and mental health status, differences in outcome types, life-course approaches, and contextual moderators of inequalities. Future studies in this area can deal with the challenges and aid policymakers in establishing relevant and timely intervention strategies.

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TABLES

Table 2.1. General characteristics of the 96 studies included in the review

Characteristics	All studies (N=96)	
	N	%
Year of publications		
Before 1990	1	1.0%
1990-1999	6	6.3%
2000-2008	34	35.4%
2009-2018/01	55	57.3%
Study design		
Cohort	55	57.3%
Case-control	21	21.9%
Repeated cross-sectional	7	7.3%
Cross-sectional	13	13.5%
Regions		
Nordic countries	43	44.8%
Other European countries	12	12.5%
Asia	14	14.6%
North America	14	14.6%
Oceania	11	11.5%
Multi-national	2	2.1%
Gender stratification		
Gender stratified	44	45.8%
Not stratified	41	42.7%
Men only	9	9.4%
Women only	2	2.1%
Data source		
Survey, Census, Questionnaire, Vital statistics	67	69.8%
Administrative data	29	30.2%
Suicide outcomes		
Deaths	69	-
Attempts	24	-
Ideation	17	-
Other	2	-
Socioeconomic position (death/attempt/ideation)*		
Education	56/12/9	-
Income	36/13/9	-
Occupation or occupation-based social class	13/6/5	-
Employment status	54/14/10	-
Other	35/13/7	-

Table 2.2. Results from quantitative studies (n=96) addressing SEI in suicidal behaviour or the associations between SEP and suicidal behaviour

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Lorant et al. ¹ , (2018), 13 European countries	Assess trends in SEI in suicide in 15 EU populations	NS	death (U)	35-79 (1991-2006)	CO (R)	Education (tertiary)	-	2.12 (2.04,2.19)	-	N	N	L
Puzo et al. ² (2018), Norway	Compare SEI in suicide according to nativity status	S	death (U)	all (1992-2012)	CC (R)	Income (≥400K NOK)	-	M: 2.81 (2.56,3.09) F: 4.49 (3.63,5.55)	I, F	N	N	N
Yoon et al. ³ (2017), South Korea (KOWEPS)	Test the association between change in precarious employment and suicidal ideation	NS	ideation	all (2012-2015)	CS	Employment (permanent)	4.74 (1.95,11.54)	3.94 (1.46,10.64)	F, M(Q)	N	N	N
Han et al. ⁴ , (2017), South Korea (KNHANES)	Test the association between precarious employment and suicidal ideation	NS	ideation	≥19 (2010-2012)	RC	Employment (non-precarious)	1.81 (1.49,2.20)	M: 1.78 (1.19,2.67) F: 0.97 (0.73,1.29)	F, M(P)	N	N	N
Borrell et al. ⁵ (2017), Basque and Barcelona, Spain	Examine SEI in suicide mortality around the 2008 economic recession	S	death	≥25 (2001-2012)	CO	Education	M: 4.54 (RII) F: 2.76 (RII)	-	-	N	N	E
Lee et al. ⁶ (2017), South Korea	Identify the association between SEP and suicide	S	death	≥10 (1991-2006)	CO (R)	Income (10th decile)	M: 3.73 (2.93,4.76) F: 2.62 (1.93,3.55)	M: 2.74 (2.12,3.52) F: 1.68 (1.23,2.30)	-	N	N	N
Liu (2017) ⁷ , Stockholm in Sweden	Test effects of neighborhood context on suicide	NS	death (U)	16-65 (2003-2013)	CO (R)	Social welfare (non-receipts)	-	4.41 (3.89,5.00)	E, F	N	ML	N
Pirkis et al. ⁸ (2017), Australia	Examine the relationship between individual- and area-level SEP and suicidal ideation	M	ideation	18-55 (2013/14)	CS	Employment (high skilled)	4.19 (3.44-5.10)	1.83 (1.40-2.37)	F, M(P)	N	ST	N
Bálint et al. ⁹ (2016), Hungary	Examine the effects of education on suicide and the long-term trends	S	death (U)	≥20 (1980, 1990, 2001, 2011)	CO	Education (tertiary)	-	M: 3.49 (2.67,4.57) F: 2.74 (1.72,4.37)	F	N	N	L
Kimura et al. ¹⁰ (2016), Japan	Examine the association between education and suicide	S	death	40-59 (1990-2011)	CO	Education (lower secondary)	-	M: 0.43 (0.22,0.85) F: 0.44 (0.24,0.79)	F, M(P)	N	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Kim et al. ¹¹ (2016), South Korea	Examine the association between SEP and suicide attempts	S	attempt	≥19 (2013)	CS	Education (tertiary)	-	M: 2.41 (1.05,5.56) F: 5.35 (1.75,16.34)	F, M(P)	N	N	N
Wada and Gilmour ¹² (2016), Japan	Test temporal trends in occupation-specific mortality for 3 decades	M	death	30-59 (1980,85,90,95, 2000, 05, 10)	RC	Employment (other)	-	7.75 (6.55,9.18)	-	N	N	E
Katrnák and Tyrychtrová ¹³ (2016), Czech republic	Test the effects of low education on suicide	NS	death	15-80 (1991-2006)	RC	Education (primary)	0.28	0.37	F	N	N	L
Song and Lee ¹⁴ (2016), South Korea	Investigate the association between food sufficiency and suicidality	S	ideation, attempt	≥19 (2007-2012)	CS	Food sufficiency (sufficient)	-	M: 2.83 (1.15,6.96) F: 2.18 (1.25,3.83)	F	N	N	N
Chang et al. ¹⁵ (2015), South Korea	Assess the association between childhood adversities and lifetime suicidality	NS	ideation, plan, attempt	≥18 (2006-2011)	CO	Financial situation (no)	2.99 (1.08,8.31)	2.88 (1.04,8.00)	-	C	N	N
Grande et al. ¹⁶ (2015), South Australia	Assess the association of SEP in childhood and adulthood with suicidality	NS	ideation	≥25 (2009-2011)	CS	Financial situation (high-high)	3.64 (2.79,4.73)	3.55 (2.72,4.63)	F	CO	N	N
Denney et al. ¹⁷ (2015), US	Investigate the role of social context on individual suicides	NS	death	≥18 (1986-2006)	CO	Employment (employed)	-	1.45	F, R	N	ML	N
Rojas and Stenberg ¹⁸ (2015), Sweden	Explore the extent to which suicides being faced with an eviction is related to suicide	NS	death (U)	≥16 (2009-2013)	CO (R)	Eviction (no eviction)	8.84 (6.54,12.98)	4.42 (2.95,6.64)	F, M(D), I	N	N	N
Wetherall et al. ¹⁹ (2015), England, UK	Test the association between income and suicidality is accounted for by the rank of that income within comparison groups	NS	ideation, attempt	≥16 (2007)	CS	Income (continuous)	-	0.45 (0.34-0.61)	F	N	N	N
Min et al. ²⁰ (2015), South Korea	Test the effect of precarious employment on suicidality	NS	ideation, attempt	20-59 (2008)	CS	Employment (non-precarious)	4.01 (2.86,5.62)	1.52 (1.02,2.27)	F, M(P)	N	N	N
Davison et al. ²¹ (2015), Canada	Examine the effect of food insecurity on suicidality	NS	ideation	≥18 (2007)	CS	Food insecurity (no insecurity)	2.79 (2.25,3.44)	1.77 (1.42,2.23)	F, M(P)	N	N	N
DalGLISH et al. ²² (2015), France	Test associations between job insecurity, unemployment, and suicidality	NS	ideation	18-37 (2011)	CO	Employment (no job insecurity)	-	9.28 (1.19,72.33)	F, M(P)	N	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Di Thiene et al. ²³ (2015), Sweden	Investigate to what extent suicide risk in immigrants is associated with labour market marginalization	S	death (U)	16-50 (2005-2010)	CO (R)	Employment (employed)	-	-	I, M(S), F	N	N	N
Lee et al. ²⁴ (2014), South Korea	Examine whether the socioeconomic context of urban areas affects suicides	NS	death	≥35 (2003-2008)	RC	Education (tertiary)	4.09 (3.89,4.30)	4.05 (3.85,4.26)	-	N	ML	N
Milner et al. ²⁵ (2014), Australia	Assess changes in suicides by employment status around the 2008 economic crisis	S	death	15-64 (2001-2010)	CO	Employment (employed)	M: 7.96 (7.32,8.65) F: 11.28 (10.27,13.68)	-	-	N	N	E
Milner et al. ²⁶ (2014), Australia	Examine the relationship of involuntary job loss to suicide	NS	death, attempt	18-34 (2004-2010)	CC	Social class (high)	4.50 (2.06,9.82)	3.85 (1.59,9.35)	F, M(P)	N	N	N
Zammit et al. ²⁷ (2014), Sweden	Test if area-level characteristics during childhood are associated with suicide	NS	death (U)	26-31 (1972-2003)	CO (R)	Parent SEP (middle)	1.77 (1.01,3.07)	1.04 (0.53,1.78)	F, M(D), I	B	ML	N
Geoffroy et al. ²⁸ (2014), England, Wales, and Scotland, UK	Elucidate early life antecedents of suicide	NS	death (U)	0-50 (1958-2009)	CO	Father's occupation (nonmanual)	1.94 (0.91,4.13)	-	F	C	N	N
Crump et al. ²⁹ (2014), Sweden	Test sociodemographic, psychiatric, and somatic risk factors on suicide	S	death	≥18 (2001-2008)	CO (R)	Employment (employed)	M: 2.26 (2.11,2.43) F: 3.06 (2.74,3.41)	M: 1.66 (1.54,1.78) F: 1.97 (1.76,2.20)	F, M(D), I	N	N	N
Pompili et al. ³⁰ (2013), Italy	Test if education was associated with suicide	S	death	≥15 (2006-2008)	RC	Education (≤5yrs)	M: 1.93 (1.50,2.10) F: 2.57 (1.98,3.35)	M: 1.59 (1.34,1.88) F: 2.02 (1.55,2.64)	F	N	N	N
Garcy and Vågerö ³¹ (2013), Sweden	Test the validity of social causation and social drift hypotheses	S	death (U)	28-71 (1993-2002)	CO (R)	Employment (employed)	M: 1.75 (1.61,1.91) F: 1.39 (1.20,1.62)	M: 1.48 (1.33,1.63) F: 1.26 (1.04,1.54)	F, I, M(D)	N	N	E
Yamauchi et al. ³² (2013), Japan	Examine suicide risk by marital and employment status	S	death	≥15 (1980,85,90,95, 2000, 05)	CO	Employment (employed)	-	M: 3.72 (3.54,3.90) F: 3.42 (3.13,3.73)	F	N	N	L
Kosidou et al. ³³ (2012), Sweden	Test the relationship between immigrant status, employment status, and suicidality	S	attempt	18-29 (2002-2006)	CS (R)	Welfare (none)	M: 3.75 (2.44,5.78) F: 2.82 (2.06,3.87)	M: 3.11 (1.96,4.92) F: 1.92 (1.37,2.71)	F, E, I, M(A)	N	N	N
Lundin et al. ³⁴ (2012), Sweden	Test the relationship between unemployment and suicide	S	death	25-58 (1994-1995)	CO (R)	Employment (upper nonmanual)	M: 2.33 (1.30,4.20) F: 3.54 (1.87,6.70)	M: 1.59 (0.86,2.93) F: 2.54 (1.19,5.45)	M(S)	N	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Von Borczyskowski et al. ³⁵ (2011), Sweden	Examine socioeconomic determinants of suicide separated from the heredity	NS	death	19-55 (1987-2001)	CO (R)	Housing (owner)	1.45 (1.07,1.97)	1.82 (1.09,3.06)	F	B	N	N
Danziger et al. ³⁶ (2011), Stockholm, Sweden	Examine effects of early life conditions on adulthood suicide	NS	death (U)	31-87 (1960-2002)	CO	Occupation (nonmanual)	2.11 (1.21,3.68)	1.48 (0.61,3.64)	F	B	N	N
Burrows et al. ³⁷ (2011), Canada	Examine the association between social disadvantage and suicide and if it was modified by area deprivation	S	death (U)	≥25 (1991-2001)	CO	Employment (employed)	M: 2.18 (1.96,2.43) F: 2.24 (1.93,2.61)	M: 1.50 (1.34,1.68) F: 2.10 (1.78,2.48)	F,E,I	N	ST	N
Sareen et al. ³⁸ (2011), US	Examine the relationship between income, mental disorders, and suicidality	NS	attempt	≥20 (2004-2005)	CO	Income (≥70k)	-	3.66 (2.56,5.24)	F,R, M(Q)	N	N	N
Christiansen et al. ³⁹ (2011), Denmark	Test the dose-response effect of multiple parental risk factors on offspring's risk for suicidality	S	attempt	16-22 (1988-2003)	CC (R)	Income (highest third)	M: 2.71 (2.21,3.31) F: 2.42 (2.19, 2.67)	1.05 (0.91,1.21)	F, M(D)	N	N	N
Corcoran and Arensman ⁴⁰ (2011), Ireland	Test the association between unemployment and suicide as macro-economy changes	S	death (U)	≥15 (1996-2006)	RC	Employment (employed)	M: 3.63 (2.69,3.50) F: 8.61 (4.25,17.42)	-	-	N	N	E
Mäki and Martikainen ⁴¹ (2010), Finland	Test the association between unemployment and suicide during different levels of national unemployment	S	death (U)	25-64 (1988-2003)	CO (R)	Employment (stably employed)	M: 3.79 F: 3.69	M: 2.72 F: 3.27	F	N	N	E
McMillan et al. ⁴² (2010), US	Examine the relationship between income, psychological tests and suicidality	NS	ideation, attempt	≥18 (2001-2003)	CS	Income (≥USD 70k)	-	2.15 (1.55-2.98)	F,R, M(Q)	N	N	N
Rojas and Stenberg ⁴³ (2010), Stockholm in Sweden	Examine the relationship between early life circumstances and suicide	M	death (U)	17-44 (1970-1984)	CO	Social welfare (no)	-	2.18	F	N	N	N
Denney ⁴⁴ (2010), US	Explore the effects of detailed living arrangements on suicide	NS	death	≥19 (1986-2002)	CO	Employment (employed)	-	1.58	F,R	N	N	N
Strand et al. ⁴⁵ (2010), Norway	Determine the extent to which SEI in mortality widened	S	death	45-64 (1960-2000)	CO	Education	M: 18 (SII) F: NS	-	-	N	N	L
Kristensen et al. ⁴⁶ (2010), Norway	Estimate how much SEI in suicide depended on parental and individual characteristics	M	death	29-37 (1996/2000-2004)	CO (R)	Education (high-high)	-	6.3 (3.0,13.4)	F,M(C)	CO	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Kim et al. (2010) ⁴⁷ , South Korea	Describe SEI in suicidal behaviour	S	ideation, attempt, death	≥15 (1995,98, 2000, 01,05)	RC	Education	M: 16,9 (RII) F: 12.1 (RII)	-	-	N	N	E
Andre's et al. ⁴⁸ (2010), Denmark	Estimate the impact of SEP on suicide by gender	S	death	18-65 (1981-1997)	CC (R)	Income (highest)	M: 9.6 (8.9,10.2) F: 2.3 (2.1,2.6)	M: 3.8 (3.4,4.2) F: 1.7 (1.5,2.1)	F,E, M(S,A)	N	N	N
Gravseth et al. ⁴⁹ (2010), Norway	Examine suicide from life course perspectives	S	death	≥19 (1986-2004)	CO (R)	Education (upper secondary)	M: 2.42 (2.10,2.79) F: 2.58 (1.96,3.39)	M: 2.00 (1.70,2.35) F: 2.29 (1.71,3.07)	F, M(C)	Y	N	N
Lundin et al. ⁵⁰ (2010), Sweden	Investigate the association between unemployment and mortality, controlling risk factors over life course	M	death	≥44 (1995-2003)	CO (R)	Employment (not unemployed)	3.1 (1.63,5.9)	1.02 (0.42,2.53)	F, M(C,D, S)	B	N	N
Collings et al. ⁵¹ (2009), New Zealand	Investigate the association between neighborhood fragmentation and suicide	NS	death	20-74 (1996-1999)	CO	Education (post-secondary)	1.43 (1.21,1.68)	1.46 (1.15, 1.85)	A,F	N	ML	N
Denney et al. ⁵² (2009), US	Examine the relationship between suicide and family and SEP	S	death	≥18 (1986-2002)	CO	Employment (employed)	-	M: 1.38 F: 1.95	R,F	N	N	N
Mäki and Martikainen ⁵³ (2009), Finland	Analyse the effects and interrelationships of plural SEP	W	death (U,A)	25-64 (1991-2001)	CO (R)	Employment (employed)	6.65	3.98	F	N	N	N
Page et al. ⁵⁴ (2009), Australia	Investigate SEP as antecedents to attempted suicide	S	attempt	20-64 (1997)	CS	Employment (employed)	M: 3.41 (1.84,6.01) F: 3.18 (1.67,6.04)	M: 2.45 (1.30,4.62) F: 2.54 (1.31,4.92)	M(Q)	N	N	N
Bernburg et al. ⁵⁵ (2009), Iceland	Examine the contextual effect of community household poverty on adolescent suicidal behaviour	NS	ideation, attempt, suggestion	15-16 (2006)	CO	Poverty (no)	1.23	1.25	F,I	N	ML	N
Mäki and Martikainen ⁵⁶ (2008), Finland	Examine health and social outcomes among children related to parental SEP	M	death (U,A)	25-64 (1986-2004)	CO (R)	Employment (employed)	2.99	1.97	F	N	N	N
Weitoft et al. ⁵⁷ (2008), Sweden	Investigate the extent to which outcomes varied with duration of assistance and family income	NS	attempt	3-18 (1993-2002)	CO (R)	Social welfare (no)	3.12 (2.80,3.47)	1.82 (1.61,2.05)	F,E	B	N	N
O'reilly et al. ⁵⁸ (2008), Northern Ireland, UK	To test if area factors are independently related to suicide after controlling individual risks	NS	death	16-74 (2001-2006)	CO	Deprivation (least deprived)	5.68 (3.43,9.40)	1.92 (1.08,3.39)	F	N	GEE	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Blakely et al. ⁵⁹ (2008), New Zealand	Examine disparities between income and mortality during major macroeconomic reform	S	death	1-74 (1981-2001)	CO	Income	M: 2.60 (RII) F: 2.18 (RII)	-	-	N	N	L
Osler et al. ⁶⁰ (2008), Copenhagen, Denmark	Examine how impaired childhood development affect suicidal behaviour	M	death, attempt	18-49 (1972-2003)	CC (R)	Education (upper secondary)	3.41 (2.12,5.50)	2.28 (1.30,4.00)	F,M(C)	Y	N	N
Agerbo et al. ⁶¹ (2007), Denmark	Investigate if individual suicide in relation to employment status differs depending on municipality characteristics	S	death	25-60 (1982-1997)	CC (R)	Employment (employed)	M: 8.00 (7.26,8.86) F: 5.69 (4.91-6.60)	M: 7.98 (7.20,8.85) F: 5.65 (4.87,6.55)	-	N	GEE	N
Fergusson et al. ⁶³ (2007), Christchurch, New Zealand	Examine the linkages between unemployment and suicidality	NS	ideation, attempt	16-25 (1995-1998)	CC	Employment (employed)	3.08 (1.88,5.05)	1.72 (0.89,3.32)	F,M(Q)	N	N	N
Naess et al. ⁶⁴ (2007), Norway	Assess the impact of childhood and adulthood SEP on deaths	S	death	30-61 (1990-2001)	CO	Adulthood income	M: 2.14 (RII) F: 2.29 (RII)	-	-	B	N	N
Strand and Kunst ⁶⁵ (2006), Norway	Describe the association between childhood SEP and suicide mortality in adulthood	S	death (U)	25-56 (1990-2001)	CO	Father's education (basic)	M: 0.80 (0.63,1.01) F: 1.95 (1.38,2.77)	M: 1.19 (0.92,1.53) F: 2.54 (1.73,3.74)	F	B	N	N
Lawlor et al. ⁶⁶ (2006), Sweden	Examine associations of parental social class with mortality	S	death	10-57 (1970-2001)	CO	Parental occupation (non-manual)	M: 1.15 (1.09,1.20) F: 1.03 (0.96,1.11)	M: 1.03 (0.96,1.10) F: 0.92 (0.83,1.02)	F	B	N	N
Ahs and Westerling ⁶² (2006), Sweden	Estimate if the risk for mortality was related to employment status during high and low levels of unemployment	NS	death (U)	18-64 (1984-89 or 1992-97)	CO	Employment (employed)	-	2.28 (1.96,2.66)	F,I	N	N	N
Agerbo et al. (2006) ⁶⁷ , Denmark	Study associations between suicide, psychiatric admission, SEP, and family status	NS	death	all (1981-1997)	CC (R)	Employment (employed)	2.51 (2.16,2.91)	1.76 (1.49,2.08)	F,M(A)	N	N	N
Riordan et al. ⁶⁸ (2006), Scotland, UK	Examine the relationship between perinatal circumstances and adult suicide	NS	death (U)	12-34 (1981-2003)	CO	Parental occupation (professional)	2.10 (1.76,2.49)	1.69 (1.42,2.03)	F	C	N	N
Kim et al. ⁶⁹ (2006), South Korea	Examine the effects of SEP on suicide	S	death	20-64 (1982-1997)	CC	Occupation (social class I)	M: 2.35 (2.03,2.72) F: 2.67 (2.01,3.54)	M: 1.26 (1.02,1.55) F: 2.11 (1.57,2.84)	F	N	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Kim et al. ⁷⁰ (2006), South Korea	Examine the association between precarious employment and mental health outcomes	S	ideation	20-64 (1998)	CC	Employment (standard)	M: 1.31 (0.95,1.81) F: 1.62 (1.19,2.20)	M: 1.29 (0.93,1.78) F: 1.62 (1.19,2.22)	F	N	N	N
Lorant et al. ⁷¹ (2005), 10 European countries	Show overview of SEI in suicide in Europe	S	death (U)	all (1990-1997)	CO	Education (tertiary)	M: 1.43 (1.38,1.47) F: 0.92 (0.88,0.97)	-	-	N	N	N
Agerbo et al. ⁷² (2005), Denmark	Show the association between employment status and suicide with psychiatric disorders	NS	death	25-60 (1982-1997)	CC (R)	Employment (employed)	-	1.67 (1.60-179)	F,M(A)	N	N	N
Mittendorfer-Rutz et al. ⁷³ (2004), Sweden	Examine the relations between fetal growth, mother's SEP and suicidality (R)	NS	death (U), attempt (U)	0-16 (1973-1999)	CC	Mother's education (≥13 yrs)	-	1.54 (1.44,1.65)	-	C	N	N
Pensola and Martikainen ⁷⁴ (2004), Finland	Determine to what extent social class differences in mortality are explained by childhood and adulthood factors (R)	M	death	31-42 (1991-1998)	CO	Occupation (upper nonmanual)	5.24 (3.86,7.12)	2.04 (1.36,3.07)	F	B	N	N
Taylor et al. (2004) ⁷⁵ , Australia	Examine social determinants of suicidality	S	attempt	20-64 (1997)	CO	Occupation (high)	M: 3.8 F: 4.6	M: 3.4 F: 4.0	M(Q)	N	N	N
Voss et al. ⁷⁶ (2004), Sweden	Examine the association between unemployment and mortality	S	death (U)	15-70 (1973-1996)	CC	Employment (never unemployed)	M: 1.1 (0.4,3.2) F: 5.3 (1.6,18.0)	M: 0.9 (0.3,2.6) F: 3.7 (1.0,13.0)	F,M(P)	N	N	N
Christoffersen et al. ⁷⁷ (2003), Denmark	Surveys possible risk factors of suicidality	NS	attempt	14-27 (1981-1993)	CC	Employment (employed)	5.6 (4.9,6.4)	2.9 (2.5,3.5)	F,M(A)	B	N	N
Kraut and Walld ⁷⁸ (2003), Manitoba, Canada	Examine the association between employment status and suicidality	NS	attempt (U)	15.-64 (1986-1990)	CO	Employment (employed)	-	3.68 (1.76,7.71)	F,A, M(D)	N	N	N
Qin et al. ⁷⁹ (2003), Denmark	Examine the joint effect of multiple factors on suicide	S	death	all (1981-1997)	CC (R)	Employment (employed)	-	M: 3.26 (2.97,3.57) F: 1.88 (1.63,2.18)	F,M(A), E	N	N	N
Westman et al. ⁸⁰ (2003), Sweden	Test the association between place of birth and suicidality	S	attempt (U)	25-64 (1993-1998)	CO	Income (high)	-	M: 4.06 (3.79,4.34) F: 1.46 (1.41-1.57)	F,E	N	N	N
Blakely et al. ⁸¹ (2003), New Zealand	Determine the independent associations of employment status and SEP with suicide	S	death	18-64 (1991-1994)	CC	Employment (employed)	M: 3.16 (2.40,4.17) F: 2.57 (1.68,3.94)	M: 2.59 (1.89,3.55) F: 2.63 (1.63,4.25)	F	N	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Pensola and and Martikainen ⁸² (2003), Finland	Assess the effects of parental and adulthood SEP paths in mortality	W	death	31-42 (1991-1998)	CO (R)	Occupation (upper nonmanual)	3.02 (1.75,5.30)	2.46 (1.24,4.89)	F	B	N	N
Fu et al. ⁸³ (2002), US	Examine genetic influences on suicidality	S	ideation, attempt	33-53 (1987-1992)	CC (R)	Employment (unemployed)	0.20 (0.12,0.33)	0.19 (0.11,0.34)	F,R, M(D)	N	N	N
Alaimo et al. ⁸⁴ (2002), US	Examine the relationship between food insufficiency and mental health outcomes	NS	ideation, attempt	15-16 (1988-1994)	CS	Food insufficiency (no)	-	5.0 (1.7,14.6)	R,F	N	N	N
Borrell et al. ⁸⁵ (2002), Barcelona in Spain	Analyse the role of predictors in SEI of injury mortality	S	death	≥20 (1992-1998)	CO	Education (secondary)	M: 1.89 (1.38,2.60) F: 1.16 (0.75-1.80)	-	-	N	N	N
Kposowa ⁸⁶ (2001), US	Examine the effect of employment status on suicide	S	death (U)	≥15 (1979-1989)	CO	Employment (employed)	-	M: 2.30 (1.16,4.54) F: 3.85 (1.45,10.20)	F,R	N	N	N
Qin et al. ⁸⁷ (2000), Denmark	Test if the risk factors for suicide differ by gender	S	death	all (1982-1994)	CC (R)	Employment (working)	M: 4.12 (2.93,5.75) F: 4.91 (3.26,7.42)	M: 0.78(0.50,1.21) F: 1.24 (0.72,2.13)	M(A),F	N	N	N
Mortensen et al. ⁸⁸ (2000), Denmark	Assess the RR and PAR of suicide associated with SEP and mental illness	NS	death	16-78 (1980-1994)	CC	Employment (working)	1.89 (1.50,2.38)	1.35 (1.03,1.76)	M(A),F	N	N	N
Cubbin et al. ⁸⁹ (2000), US	Examine multilevel correlates of injury mortality	NS	death	18-64 (1987-1995)	CO	Employment (white collar)	-	2.05	R,F	N	P	N
Goodman (1999) ⁹⁰ , US	Determine whether SEI in suicidality exists among the youth	NS	attempt	11-21 (1994)	CS	Income (not given)	0.85 (0.77,0.94)	0.84 (0.72,0.98)	R,F	N	N	N
Kung et al. ⁹¹ (1998), US	Examine of suicide risk factors differ by race with SEP adjusted	NS	death	25-64 (1986)	CC	Education (<12 yrs)	-	1.91 (1.37,2.67)	M(P), R,F	N	N	N
Lewis and Sloggett ⁹² (1998), England and Wales, UK	Examine the association between suicide and SEP	NS	death (U)	≥15 (1983-1992)	CO	Employment (employed)	3.71 (2.46,5.59)	2.52 (1.60,3.96)	F	N	N	N
Beautrais et al. ⁹³ (1998), Christchurch, New Zealand	Examine the association between unemployment and suicidality	S	death	13-88 (1991-1994)	CC	Employment (currently not unemployed)	M: 4.1 (2.3,7.3) F: 5.1 (2.1,12.1)	1.7 (0.8,3.5)	M(Q)	B	N	N

Author, Year of Publication, Country	Study Aim	Gender	Outcome	Age of Study Population (year of death/outcome)	Study design	SEP measure	RR/OR (95% CI) Unadjusted	RR/OR (95% CI) Adjusted	CV	LC	CF	RM
Johansson et al. ⁹⁴ (1997), Sweden	Determine the influence of ethnicity, social factors and psychiatric and somatic illness on suicide	NS	death (U)	16-84 (1979-1985)	CO	Car ownership (yes)	2.33 (1.67,3.26)	1.46 (1.01,2.12)	I,F	N	N	N
Martikainen ⁹⁵ (1990), Finland	Test whether unemployment is related to mortality	M	death	30-54 (1981-1985)	CO	Employment (employed)	2.61	1.92 (1.62,2.27)	M(P),F	N	N	N
Iversen et al. ⁹⁶ (1987), Denmark	Examine relative mortality between the employed and unemployed rate	S	death	20-64 (1970-1980)	CO	Employment (employed)	M: 2.51 (2.12,2.97) F: 2.45 (1.72,3.49)	-	F	N	N	N

Notes: Tables are sorted by (1) Name of Authors, backgrounds and year of publication (2) Study aim (3) Gender (S: gender stratified analysis, NS: non-stratified) (4) Outcome: types of suicide outcome (death (U) :deaths of undetermined intents) (5) Age of study population and follow-up years (6) Study design (CO: cohort, CC: case-control, RC: repeated cross-sectional, CS: cross-sectional) (7) SEP measure (reported in the present table) (8) RR/OR (95% CI) Unadjusted: relative risk or odds ratio (unadjusted value) at the 95% confidence interval (9) RR/OR (95% CI) Adjusted: relative risk or odds ratio (unadjusted value) after adjusting for all covariates at the 95% confidence interval (10) CV: Key covariates (F: family status; I: immigration status; R: racial status; A: aboriginal status; E: ethnicity; M(Q): mental health status measured by standardized questionnaires; M(A): mental health status measured by hospital admission status; M(D): mental health status measure by inpatient and outpatient diagnosis; M(P): perceived mental health status (or self-reported diagnoses); M(C) mental health status measured by conscription test); M(S) sickness absence records (11) LC: Life course perspective (Y: yes; N: no) (12) CF: contextual factors considered (ML: random-intercept or random-coefficient model; GEE: generalised estimating equation model; ST: stratified by regional factors; P: pooled analysis) (13) RM: repeatedly measured inequalities (L: considering long-term trends; E: considering macro-economic changes by dividing periods; N: not repeatedly measured)

Table 2.3. Results of study by gender, SEP measures and type of suicidal behaviour

A. Suicide deaths

	Educational attainment (39/56 studies)	Income (29/36 studies)	Occupation or occupation-based social class (12/13 studies)	Employment status (51/54 studies)	Other SEP indicators (22/35 studies)
Positive association					
Gender Not Stratified	<p>Lorant et al., 20018 (OR: 2.12, ref=high education) Katrnak and Tyrychtrova, 2016 (OR: 0.28, ref=primary) Davison et al., 2015 (OR: 0.68, ref=post-secondary graduate) Denney et al., 2015 (OR: 1.28, ref=more than high school) Lee et al., 2014 (OR: 4.09, ref=university) Denney, 2010 (HR: 1.29, ref=more than high school) Collings et al., 2009 (RR: 1.43, ref=post-school qualification) Agerbo et al., 2006 (RR: 0.27, ref=primary) (population based controls)</p>	<p>Davison et al., 2015 (OR: 1.60, ref=adequate household income) Zammit et al., 2014 (OR: 0.64, ref=per standard deviation) Denney, 2010 (HR: 1.14, ref=highest third) Agerbo et al., 2006 (RR: 5.50, ref=primary) (population based controls) Mortensen et al., 2000 (IRR: 2.33, ref=upper quartile)</p>	<p>Danziger et al., 2011 (HR: 2.11, ref=non-manual) Kung et al., 1998 (OR: 1.79, ref=white-collar) (Caucasian) Lewis and Sloggett, 1998 (OR: 1.89)</p>	<p>Davison et al., 2015 (OR: 1.97, ref=employed) Denney, 2015 (HR: 1.45, ref=employed) Denney, 2010 (HR: 1.58, ref=employed) O'Reilly, 2008 (HR: 2.65, ref=employed) Agerbo et al., 2006 (RR: 2.51, ref=fully employed) Ahs and Westerling, 2006 (HR: 2.28, ref=employed) Agerbo et al., 2005 (RR: 1.67, ref=fully employed for 2 years) Cubbin et al., 2000 (HR: 2.05, ref=white collar) Mortensen et al., 2000 (IRR: 1.89, ref=working) Lewis and Sloggett, 1998 (OR: 3.71, ref=employed)</p>	<p>Liu, 2017 (OR: 4.41, ref=non-welfare recipients) Davison et al., 2015 (OR: 2.79, ref=no food insecurity) Rojas and Sternberg, 2015 (OR: 8.84, ref=no eviction) Milner et al., 2014^b (OR: 3.85, ref=high socioeconomic status) Zammit et al., 2014 (OR: 1.77, ref=parental middle social class) Von Borczyskowski et al., 2011 (HR: 1.45, ref=own house) O'Reilly, 2008 (HR: 5.68, ref=least deprived) Riordan et al., 2006 (HR: 2.1, ref=parental occupation professional) Hjern et al., 2004 (HR: 4.3, ref=general population) Mittendorfer-Rutz et al., 2004 (HR: 1.26, ref=maternal education≥13) Mortensen et al., 2000 (IRR: 3.08, ref=working) Lewis and Sloggett, 1998 (OR: 3.25, ref=owner) Johansson et al., 1997 (RR: 2.33, ref=car owner)</p>
Men	<p>Puzo et al., 2018 (OR: 1.77, ref=tertiary education) (native Norwegisns) Borrell et al., 2017 (RII: 2.98, 2001-04) Lee et al., 2017 (HR: 3.73, ref=highest decile) Bálint et al., 2016 (IRR: 3.49, ref=college, 2011)</p>	<p>Puzo et al, 2018 (OR: 2.81, ref=400000 NOK or more) (native Norwegians) Crump et al., 2014 (HR: 1.20, ref=highest quartile) Burrows et al., 2011 (HR: 2.19, ref=highest quintile) Andrés et al., 2010 (OR: 9.6, ref=highest quartile)</p>	<p>Lundin et al., 2012 (HR: 2.31, ref=higher level non-manual) Lundin et al., 2010 (HR: 2.00, ref=mid-high non-manual) Mäki and Martikainen, 2008 (RR:2.83, ref=upper non-manual, alcohol-associated suicide) Kim et al., 2006^a (OR: 2.35, ref=social class I) Pensola and Martikainen, 2004</p>	<p>Wada and Gilmour, 2016 (RR: 7.75, ref=other) Thiene et al., 2015 Crump et al., 2014 (HR: 2.26, ref=employed) Milner et al., 2014^a (RR: 7.96, ref=employed, 25-34 years) Garcy and Vägerö, 2013 (HR: 1.75, ref=employed)</p>	<p>Rojas and Stenberg, 2010 (OR: 2.18, ref=no social assistance) Lundin et al., 2010 (HR: 1.59, ref= no crowded housing) Gravseth et al., 2010 (HR: 1.58, ref=parental tertiary education) Lawlor et al., 2006 (HR: 1.15, ref=parental non-manual social class)</p>

	<p>Kimura et al., 2016 (HR: 0.43, ref=junior high school)</p> <p>Crump et al., 2014 (HR: 1.58, ref=college)</p> <p>Burrows et al., 2011 (HR: 2.10, ref=university)</p> <p>Strand et al., 2010 (SII: 18)</p> <p>Kristensen et al., 2010 (HR: 6.3, ref=parental high, own high)</p> <p>Kim et al., 2010 (RII: 10.1, 2005)</p> <p>Lundin et al., 2010 (HR: 2.39, ref= >12)</p> <p>Gravseth et al., 2010 (HR: 2.45, ref= tertiary education)</p> <p>Denney et al., 2009 (OR: 1.47, ref=more than high school)</p> <p>Mäki and Martikainen, 2008 (RR:2.45, ref=tertiary, alcohol-associated suicide)</p> <p>Kim et al., 2006^a (OR: 1.36, ref=college)</p> <p>Lorant et al., 2005 (RR: 1.43, ref=ISCED 5+)</p> <p>Pensola and Valkonen, 2004 (high: 5.16)</p> <p>Blakely et al., 2003 (RR: 0.54, ref=nil)</p> <p>Borrell et al., 2002 (RR: 1.89, ref=secondary)</p> <p>Kposowa, 2001 (RR: 1.69, ref=≥16)</p>	<p>Lundin et al., 2010 (HR: 2.44, ref= 5th quintile income)</p> <p>Denney et al., 2009 (OR: 0.81, continuous logged income)</p> <p>Mäki and Martikainen, 2008 (RR:1.74, ref=highest, alcohol-associated suicide)</p> <p>Blakely et al., 2008 (RII: 2.60)</p> <p>Agerbo et al., 2007 (RR:5.68, ref=highest fourth)</p> <p>Naess et al., 2006 (RII: 2.14)</p> <p>Kim et al., 2006^a (OR: 1.95, ref=more than 2 mil Korean W)</p> <p>Qin et al., 2003 (RR:3.26, ref=highest quartile)</p> <p>Blakely et al., 2003 (RR: 0.49, ref= less than \$20000)</p> <p>Kposowa, 2001 (RR: 1.66, ref=more than \$ 25,000)</p> <p>Qin et al., 2000 (OR: 2.34, ref=upper quartile)</p>	(RR: 7.72, ref=upper non-manual)	<p>Yamauchi et al., 2013 (OR: 3.72, ref=employed)</p> <p>Lundin et al., 2012 (HR: 2.33, ref=higher level non-manual)</p> <p>Burrows et al., 2011 (HR: 2.18, ref=employed)</p> <p>Corcoran and Arensma, 2011 (IRR: 3.63, ref=employed)</p> <p>Mäki and Martikainen, 2010 (HR: 3.79, ref=stably employed)</p> <p>Andrés et al., 2010 (OR: 4.4, ref=salaried employee)</p> <p>Lundin et al., 2010 (HR: 3.10, ref= not unemployed)</p> <p>Mäki and Martikainen, 2008 (RR:2.99, ref=employed, alcohol-associated suicide)</p> <p>Denney et al., 2009 (OR: 1.38, ref=employed)</p> <p>Agerbo et al., 2007 (RR:8.00, ref=fully employed)</p> <p>Pensola and Valkonen, 2004 (RR: 7.37, ref=stably employed)</p> <p>Qin et al., 2003 (RR: 1.18, ref=fully employed)</p> <p>Blakely et al., 2003 (RR: 3.16, ref=employed)</p> <p>Kposowa, 2001 (RR: 2.30, ref=employed)</p> <p>Qin et al., 2000 (OR: 2.21, ref=employed)</p> <p>Martikainen, 1990 (RR: 2.61, ref=employed)</p> <p>Iversen et al., 1987 (HR: 2.51, ref=employed)</p>	<p>Lorant et al., 2005 (OR: 1.73, ref=housing tenure)</p> <p>Blakely et al., 2003 (RR: 1.94, ref=two or more cars)</p> <p>Qin et al., 2000 (OR: 4.12, ref=non-social benefit)</p>
Women	<p>Lee et al., 2017 (HR: 2.62, ref=highest decile)</p> <p>Bálint et al., 2016 (IRR: 2.74, ref=college, 2001)</p> <p>Kimura et al., 2016 (HR: 0.44, ref=junior high school)</p> <p>Crump et al., 2014 (HR: 1.25, ref=college)</p> <p>Burrows et al., 2011 (HR: 1.58, ref=university)</p> <p>Kim et al., 2010 (RII: 12.1)</p>	<p>Puzo et al., 2018 (OR: 4.49, ref=400000 NOK or more) (native Norwegians)</p> <p>Burrows et al., 2011 (HR: 2.50, ref=highest quintile)</p> <p>Andrés et al., 2010 (OR: 2.3, ref=highest quartile)</p> <p>Mäki and Martikainen, 2009 (RR:1.74, ref=highest, alcohol-associated suicide)</p> <p>Blakely et al., 2008 (RII: 2.18)</p>	<p>Lundin et al., 2012 (HR: 3.09, ref=higher level non-manual)</p> <p>Mäki and Martikainen, 2009 (RR:2.78, ref=upper non-manual, alcohol-associated suicide)</p> <p>Kim et al., 2006^a (OR: 2.67, ref=social class I)</p> <p>Pensola and Martikainen, 2003 (RR: 9.07, ref=upper non-manual)</p>	<p>Thiene et al., 2015</p> <p>Milner et al., 2014^a (RR: 11.28, ref=employed, 25-34 years)</p> <p>Crump et al., 2014 (HR: 3.06, ref=employed)</p> <p>Vagerö and Garcy, 2013 (HR: 1.39, ref=employed)</p> <p>Yamauchi et al., 2013 (OR: 3.42, ref=employed) (in 2005)</p> <p>Lundin et al., 2012 (HR: 3.54, ref=higher level non-manual)</p>	<p>Lorant et al., 2005 (OR: 1.74, ref=housing tenure)</p> <p>Blakely et al., 2003 (RR: 3.31, ref=two or more cars)</p> <p>Qin et al., 2000 (OR: 4.91, ref=non-social benefit)</p>

	<p>Gravseth et al., 2010 (HR: 2.58, ref= tertiary education)</p> <p>Mäki and Martikainen, 2009 (RR: 2.43, ref=tertiary, alcohol-associated suicide)</p> <p>Kim et al., 2006^a (OR: 1.16, ref=college)</p> <p>Pensola and Martikainen, 2003</p>	<p>Agerbo et al., 2007 (RR:3.28, ref=highest fourth)</p> <p>Kim et al., 2006^a (OR: 2.98, ref=more than 2 mil Korean W)</p> <p>Naess et al., 2006 (RII: 2.29)</p> <p>Qin et al., 2003 (RR:1.88, ref=highest quartile)</p>		<p>Burrows et al., 2011 (HR: 2.24, ref=employed)</p> <p>Corcoran and Arensma, 2011 (IRR: 8.61, ref=employed)</p> <p>Mäki and Martikainen, 2010 (HR: 3.69, ref=stably employed)</p> <p>Andrés et al., 2010 (OR: 3.0, ref=highest quartile)</p> <p>Denney et al., 2009 (OR: 1.95, ref=employed)</p> <p>Mäki and Martikainen, 2009 (RR:6.65, ref=employed, alcohol-associated suicide)</p> <p>Agerbo et al., 2007 (RR:5.69, ref=fully employed)</p> <p>Voss et al., 2004 (RR: 5.3 ref=unexposed to unemployment)</p> <p>Qin et al., 2003 (RR: 1.23, ref=fully employed)</p> <p>Blakely et al., 2003 (RR: 2.57, ref=employed)</p> <p>Pensola and Martikainen, 2003</p> <p>Kposowa, 2001 (RR: 3.85, ref=manual)</p> <p>Iversen et al., 1987 (OR: 2.45, ref=employed)</p>	
No association/not significant					
Gender not stratified	<p>Mortensen et al., 2000</p> <p>Cubbin et al., 2000</p> <p>Lewis and Sloggett, 1998</p> <p>Johansson et al., 1997</p>	<p>Liu, 2017</p> <p>Denney et al., 2015</p> <p>Cubbin et al., 2000</p>	Johansson et al., 1997	Milner et al., 2014^b	Geoffroy et al., 2014 (ref=father's non manual occupation)
Men	<p>Osler et al., 2008</p> <p>Qin et al., 2000</p>			Voss et al., 2004	<p>Lundin et al., 2010 (ref=father's mid-high non-manual occupation)</p> <p>Strand and Kunst, 2006 (ref=parental upper non-manual social class, parental education)</p> <p>Naess et al., 2006 (ref=father's upper non-manual occupation)</p> <p>Qin et al., 2003 (ref=wealth upper quartile)</p> <p>Pensola and Valkonen, 2003 (ref=parental upper-non-manual)</p>
Women	<p>Puzo et al., 2018</p> <p>Borrell et al., 2017</p>	<p>Denney et al., 2009</p> <p>Blakely et al., 2003</p>		Qin et al., 2000	Gravseth et al., 2010 (ref=parental tertiary education)

	Strand et al., 2010 Denney et al., 2009 Blakely et al., 2003 Borrell et al., 2002 Kposowa, 2001 Qin et al., 2000	Kposowa, 2001 Qin et al., 2000			Lawlor et al., 2006 (ref=parental non-manual social class)
Reverse association					
Gender not stratified	Kung et al., 1998 (OR: 1.91, ref<12) (Caucasian)				
Men	Pompili et al., 2013 (OR: 1.93, ref= ≤5) (aged 25-44)				Osler et al., 2008 (RR:0.56, ref=father's occupation employed civil servant)
Women	Pompili et al., 2013 (OR: 2.57, ref= ≤5) (aged 25-44) Lorant et al., 2005 (RR: 0.92, ref=ISCED 5+)				Strand and Kunst, 2006 (RR: 1.95, ref=father's education basic) Naess et al., 2006 (RII: 0.64, ref=father's upper non-manual class) Pensola and Martikainen, 2003 (ref=parental upper non-manual) Qin et al., 2003 (RR: 0.78, ref=wealth upper quartile)

B. Suicide attempts

	Educational attainment (9/12 studies)	Income (12/13 studies)	Occupation or occupation-based social class (5/6 studies)	Employment status (13/14 studies)	Other SEP indicators (11/14 studies)
Positive association					
Gender Not Stratified		McMillan et al., 2010 (OR: 2.15, ref=more than USD 67,000) Wetherall et al., 2015 (OR: 0.45, continuous) Sareen et al., 2015 (OR: 3.66, ref=more than \$70000) Weitoft et al., 2008 (RR: 1.72, ref=highest decile) Goodman, 1999 (OR: 0.85, ref=less than high school)		Min et al., 2015 (OR: 4.01, ref=non-precarious) Milner et al., 2014 ^b (OR: 2.12, ref=no involuntary job loss) Fergusson et al., 2007 (OR: 3.08, ref=employed) Christoffersen et al., 2003 (OR: 5.6, ref=not long-term unemployed) Kraut and Walld, 2003 (OR: 3.68, ref=full-time employed)	Chang et al., 2015 (HR: 2.99, ref=no financial strain) Milner et al., 2014 ^b (OR: 3.98, ref=high socioeconomic status) Mittendorfer-Rutz et al., 2004 (HR: 1.54, ref=maternal education≥13) Bernburg et al., 2009 (OR: 1.25, ref=non-household poverty) Weitoft et al., 2008 (RR: 3.12, ref=no social assistance) Christoffersen et al., 2003 (OR: 2.1, ref=not parental long-term unemployed) Alaimo et al., 2002 (OR: 5.0, ref=food sufficiency)

Men	Kim et al., 2016 (OR: 2.41, ref=college) Song and Lee, 2016 (OR: 0.10, ref=elementary school) Osler et al., 2008 (RR:3.41, ref=high school exam) Kim et al., 2010 (RII: 16.9) Taylor et al., 2004 (OR: 2.9, ref=high social class) Fu et al., 2002 (OR: 5.36, ref=college)	Song and Lee, 2016 (OR: 0.45, ref=low income) Christiansen et al., 2011 (IRR: 2.71, ref=highest third) Westman et al., 2003 (OR: 4.06, ref=high income)	Page et al., 2009 (OR: 2.63, ref=professionals) Taylor et al., 2004 (OR: 3.8, ref=high social class)	Kim et al., 2016 (OR: 2.41, ref=unemployed) Kosidou et al., 2012 (OR: 3.18, ref=employed) Page et al., 2009 (OR: 3.41, ref=employed) Fu et al., 2002 (OR: 0.2, ref=unemployed) Beautrais et al., 1998 (OR: 4.1, ref=employed)	Song and Lee, 2016 (OR: 2.83, ref=no food insufficiency) Kosidou et al., 2012 (OR: 3.75, ref=non-financial strain)
Women	Kim et al., 2016 (OR: 5.35 ref=college) Song and Lee, 2016 (OR: 0.16, ref=elementary school) Kim et al., 2010 (RII: 12.1)	Kim et al., 2016 (OR: 1.96 ref=highest quartile) Song and Lee, 2016 (OR: 0.23, ref=low income) Christiansen et al., 2011 (IRR: 2.42, ref=highest third) Westman et al., 2003 (OR: 1.46, ref=high income)	Song and Lee, 2016 (OR: 2.16, ref=white collar) Page et al., 2009 (OR: 2.24, ref=professionals) Taylor et al., 2004 (OR: 4.6, ref=high social class)	Kosidou et al., 2012 (OR: 2.57, ref=employed) Page et al., 2009 (OR: 3.18, ref=employed) Beautrais et al., 1998 (OR: 5.1, ref=employed)	Song and Lee, 2016 (OR: 2.18, ref=no food insufficiency) Kosidou et al., 2012 (OR: 2.82, ref=non-financial strain)
No association/not significant					
Gender not stratified					Goodman, 1999 (parental education, income)
Men	Page et al., 2009	Kim et al., 2016	Song and Lee, 2016		Osler et al., 2008 (ref=father's occupation employed civil servant)
Women	Page et al., 2009 Taylor et al., 2004			Kim et al., 2016	

C. Suicidal ideation

	Educational attainment (7/9 studies)	Income (9/9 studies)	Occupation or occupation-based social class (3/5 studies)	Employment status (9/10 studies)	Other SEP indicators (6/7 studies)
Positive association					
Gender Not Stratified	Han et al., 2017 (OR: 2.32, ref=college) Davison et al., 2015 (OR: 0.68, ref=post-secondary)	McMillan et al., 2010 (OR: 1.77, ref=more than USD 67,000) Han et al., 2017 (OR: 2.07, ref=high) Wetherall et al., 2015 (OR: 0.59, continuous) Davison et al., 2015 (OR: 1.6, ref=adequate household income)	Han et al., 2017 (OR: 1.54, ref=white-collar)	Yoon et al., 2017 (OR: 4.74, ref=permanent workers->permanent workers) Han et al., 2017 (OR: 1.81, ref=non-precarious worker) Min et al., 2015 (OR: 2.45, ref=non-precarious) Davison et al., 2015 (OR: 1.97, ref=employed)	Chang et al., 2015 (HR: 1.62, ref=no financial strain) Grande et al., 2015 (OR: 3.64, ref=financial situation high(childhood)-high(adulthood) Davison et al., 2015 (OR: 2.79, ref=non-food insufficiency) Bernburg et al., 2009 (OR: 1.11, ref=non-household poverty)

		DalGLISH et al., 2015		DalGLISH et al., 2015 (OR: 9.28, ref=no job insecurity) Fergusson et al., 2007 (OR: 2.72, ref=employed)	
Men	Song and Lee, 2016 (OR: 0.49, ref=elementary school) Kim et al., 2010 (RII: 3.8) Kim et al., 2006^b (OR: 1.66, ref=college)	Song and Lee, 2016 (OR: 0.64, ref=low income) Kim et al., 2006^b (OR: 1.52, ref=high income)	Song and Lee, 2016 (OR: 2.4, ref=white collar)	Pirkis et al., 2017 (OR: 4.19, ref=high skilled occupation) Fu et al., 2002 (OR: 0.58, ref=unemployed)	Song and Lee, 2016 (OR: 2.39, ref=no food insufficiency)
Women	Song and Lee, 2016 (OR: 0.40, ref=elementary school) Kim et al., 2010 (RII: 2.4)	Song and Lee, 2016 (OR: 0.43, ref=low income) Kim et al., 2006^b (OR: 1.55, ref=high income)	Song and Lee, 2016 (OR: 1.79, ref=white collar)	Kim et al., 2006^b (OR: 1.62, ref=standard workers)	Song and Lee, 2016 (OR: 2.05, ref=no food insufficiency)
No association/not significant					
Gender not stratified					Alaimo et al., 2002 (ref=food sufficiency)
Men	Fu et al., 2002		Kim et al., 2006^b	Kim et al., 2006^b	
Women	Kim et al., 2006^b		Kim et al., 2006^b		

FIGURES

Figure 2.1. Articles on “suicide & (socioeconomic or social)” in the title or abstract for the year 1980-2018 on the PUBMED (searched in January 2018)

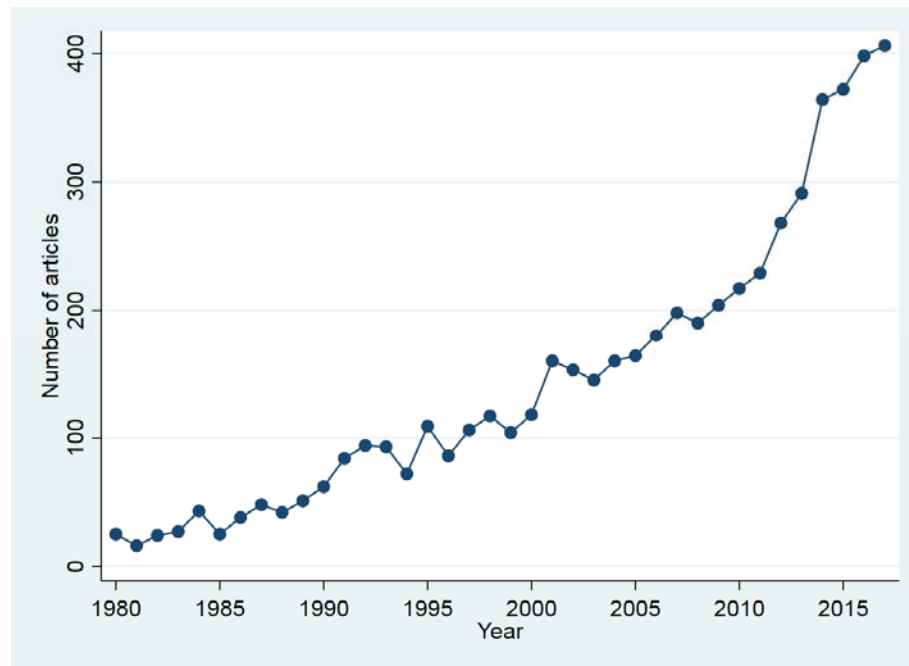
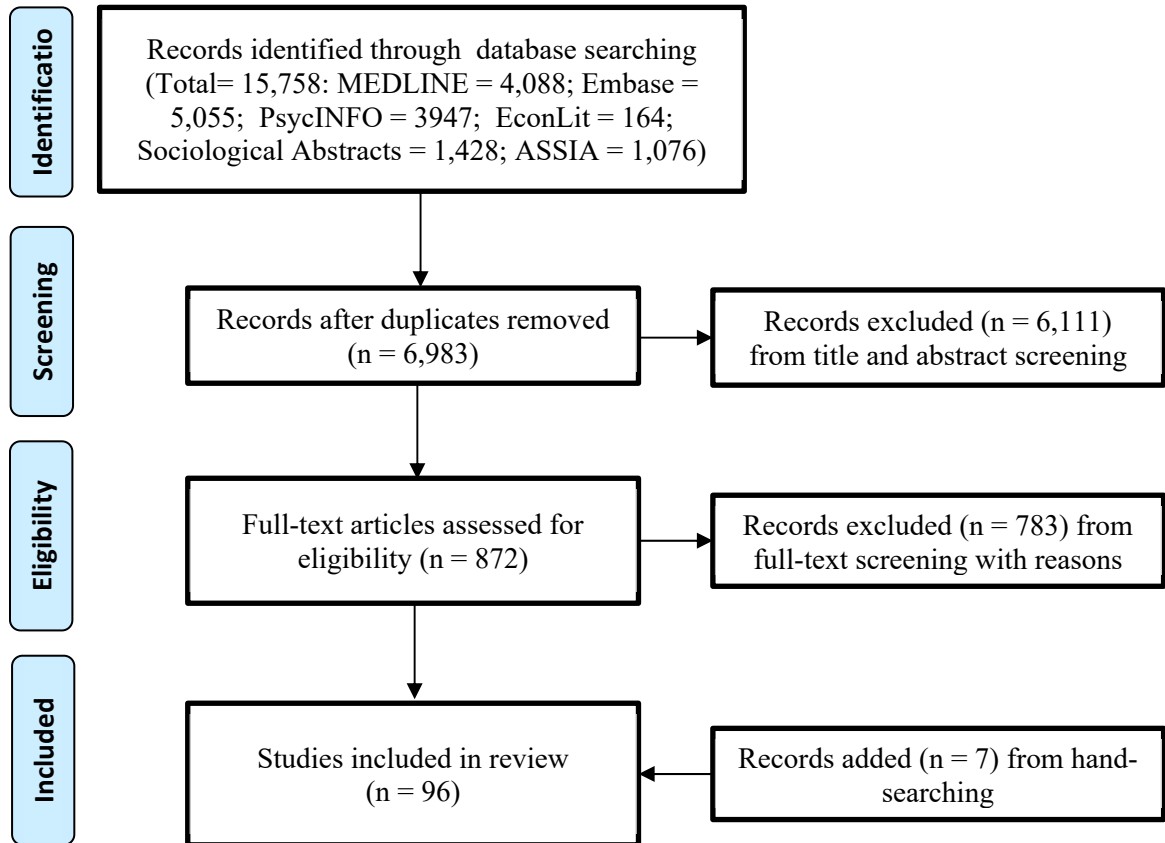


Figure 2.2. PRISMA flow diagram



CHAPTER 3

STUDY 2: EMPLOYMENT-BASED INEQUALITIES IN SUICIDE MORTALITY AND THE ROLE OF THE WELFARE STATE IN CANADIAN PROVINCES

Abstract

Objective: to investigate the impacts of welfare generosity on suicide and employment-based inequalities in suicide.

Methods: We conducted multilevel logistic regression using individual-level data from the 1991 Canadian Census Health and Environment Cohort (CanCHEC) and provincial-level data from the Canadian Socio-Economic Information Management System (CANSIM). A total of 2.2 million working-age Canadians (aged 25 or 64 years), who completed the 1991 census long form, were followed for 20 years for all causes of mortality, including suicide. Provincial total and social expenditures as a share of provincial Gross Domestic Product (GDP) were used to measure welfare generosity.

Results: Analyses reveal no significant inverse association between provincial welfare generosity and suicide mortality among employed people. However, larger proportions of social assistance expenditure and total government spending were associated with 132 and 15 hypothetical fewer suicide deaths per 100,000 respectively, among the non-employed.

Conclusions: Findings indicate that lower employment-based inequalities in suicide are associated with provincial welfare generosity in Canada. Specifically, higher total government expenditure and social assistance expenditure are associated with salutary effects for the non-employed.

Introduction

The relationship between suicide and labour market marginalization has been well established in the epidemiological literature. Previous research has suggested several possible mechanisms through which unemployment and unstable employment lead to suicidal behaviour. Among these, materialist explanations associated with social causation models are well suited for explaining the universal unemployment-related suicide inequalities¹⁻³. These accounts argue that economic deprivation from instant and anticipated income loss due to unemployment, along with subsequent life crises such as loss of housing and food insufficiency, worsens mental health status—for instance, by causing the onset of mental disorders—and elevates the risk of suicide⁴. It is not just the acute effects of income loss, but also the long-term persistent fear of economic insecurity, which brings about severe adverse impacts on mental health⁵. Previous studies reported that suicide risks were still elevated among the unemployed and those not in the labour force long after they had become unemployed^{2,6}. The materialist explanation can be acknowledged even by those who uphold social selection theory—that psychiatric disorder is a common cause of both labour market marginalization and suicide. For example, a previous study of discharged psychiatric patients found that the lowest suicide risk was shown among people who were social benefits recipients and disability pensioners, compared to those who were re-employed or unemployed³. This is underpinned by more classical and recent studies⁷⁻⁹.

Social policies that buffer the adverse effects of labour market marginalization may interrupt the pathways from financial strain to suicide¹⁰⁻¹². They may enhance the decommodification—“the extent to which individuals and families can maintain a normal

and socially acceptable standard of living regardless of their market performance,¹³—of everyday life, thereby protecting those marginalized in the labour market and their families from material deprivation and persistent insecurity. This in turn, may improve mental health and ameliorate psychological problems that can be antecedents to suicidal behaviour. Some previous studies have also argued that relatively more generous social policy may be associated with decreased suicide risk by conceptualizing the generosity of social policy as a proxy for social integration (i.e., social cohesion, connectedness, social capital)^{12,14}. Taken together, more generous social policy may be associated not only with reduced inequalities in suicide and decreased suicide risks among the marginalized in the labour market, but with decreased overall suicide mortality in society.

A common approach to testing the main and moderating impacts of welfare generosity on suicide and suicide inequalities is to exploit jurisdictional and temporal variations in welfare indicators. Many studies examining the effects of policy on suicide have conducted time-series analyses with multiple countries or states with aggregate data¹². Although most of these studies find that relatively more generous social policy has main or moderating impacts^{15–17}, a problem with such approaches is that it is impossible to confirm whether social policy is effective for those who have actually experienced labour market marginalization. This is in part attributable to the limitations of studies relying solely on aggregate-level data. A possible alternative is to incorporate individual-level factors into models, but no cross-level analyses the relationship between social policy and suicide mortality have been published previously.

Building upon the contributions of the previous literature, the present study fills gaps by exploiting variations in welfare generosity over Canadian provinces. A challenge for

testing policy effects on suicide is that it requires comparing data from sufficiently autonomous political entities, while also requiring samples large enough for examining such a rare outcome. Sub-national government jurisdictions, such as provinces, states, or other regions, can be of use for comparing the effects of social policy, while effectively suppressing the heterogeneity in culture and history that can arise in a cross-national comparison. A previous analysis of all-cause mortality has provided the detailed rationale for arguing that Canadian provinces have enough political autonomy to have different levels of generosity in social policies¹⁸. In this comparative multi-level analysis, we use a census-mortality linked database that includes more than 6,000 suicides with socioeconomic position variables. The analysis seeks to 1) examine whether the generosity of provinces' social policies is associated with overall suicide mortality and 2) test whether welfare generosity can moderate the association between labour market marginalization and suicide in Canada.

Methods

Data

We linked two datasets: (1) the 1991 Canadian Census Health and Environment Cohort (CanCHEC), a census-mortality linked database, for variables at the individual-level, and (2) the Canadian Socio-Economic Information Management System (CANSIM) for the social expenditures of the 10 Canadian provincial governments. The CanCHEC consists of a 15% sample of non-institutional residents (20% of census-filers) aged 25 or more who completed the long-form of the 1991 Canadian Census, linked to the Canadian National Mortality Database (1991-2011) and annual Tax Summary Files (1981-2011). The long-form census collects socioeconomic information including income, employment status, educational attainment, ethnicity, and living arrangement. Detailed information about the creation of the CanCHEC database is available elsewhere¹⁹. We limited our analysis to the working-age Canadians and immigrants eligible for government social programs since our purpose is to examine employment-based inequalities. Residents living in the three northern territories of Canada were excluded due to sparse population. Approximately, 2.2 million participants were included in the data set in total. The CANSIM is Statistics Canada's computerized database of aggregate time-series socioeconomic data at the federal-, provincial-, and municipal-levels. We used averaged data from between 1990 and 2009 that include federal and provincial governments' revenue and aggregated and disaggregated expenditures.

Outcome

The outcome variable ‘Suicide death’ was defined using ICD Codes for two death categories: intentional self-harm (ICD-9 E950-959 and ICD-10 X60-X84) and undetermined intent of deaths (ICD-9 E980-E989 and ICD-10 Y10-Y34).

Individual-level variables

The principal individual-level socioeconomic measure in the study is employment status. We categorized employment status into the employed and non-employed. We aggregated the category of ‘those not in the labour force (economically inactive)/unemployed’ in response to criticisms that the conventional classification of employment status excludes those economically inactive who were long-term unemployed and thus underestimates the true extent of unemployment²⁰. Moreover, given our research question concerning the role of welfare states, those not in the labour force are more likely to be beneficiaries of both universal and means-tested social programs (e.g., being ill, looking after children, injured, disabled, etc.) than the unemployed counterparts. Moreover, the unemployed can be better conceptualized as those marginalized in the labour market who need social security. Despite the heterogeneous composition, those not in the labour force are even more vulnerable to suicide risks than the unemployed as well, as shown in a previous study using the Canadian Census Mortality Follow-up Study cohort (former version of CanCHEC).

The selection of covariates was informed by previous relevant literature: log-transformed equivalized disposable household income (continuous) to make data conform to normality, educational attainment (post-secondary; higher-secondary; lower-secondary; primary), age and the age squared term (continuous) to account for the nonlinear relationship between age and suicide, gender (men; women), family types

(single-family housing; non-single-family housing), immigration status (immigrant; non-immigrant), and self-identified Aboriginal (i.e. original inhabitants of the Canadian territories) status (Aboriginal; non-Aboriginal).

Provincial-level variables

The principal independent variable is the welfare generosity of provinces. We operationalized welfare generosity as provincial expenditures (excluding impacts of federal transfers) as a percentage share of the provincial GDP. We adopt this approach based on the autonomy of sub-national (provincial) governments to make social expenditure decisions, similar to other empirical literature of cross-national comparative political economy²¹. Some previous studies in interprovincial expenditures have used the same measures since Canadian provinces arguably have the world's highest level of fiscal decentralization regarding tax revenue and expenditures.^{22,23} This is supported by data showing that between 60-95% of the total provincial government expenditures included in this study were from the provinces' own revenue plus own-source municipal revenues, while the remaining 5-40% of revenue came from the federal transfer payments to the provinces.²⁴ These federal transfers are earmarked for health and education.²³ Moreover, using the expenditures as a share of GDP is a simple way to consider the substantial variations in other economic development factors (urbanization, differences in housing and prices etc.) across provinces without adjusting for provincial-level covariates in the multilevel model that could cause a severe multicollinearity problem^{21,25}.

Since individual-level variables were measured only at baseline, we used averaged data across 1990-2009. Five relevant measures of government expenditure and social policy

were used to measure welfare generosity (All five measures of spending were divided by the provincial GDP):

- (1) Total government spending: Total expenditures by *provincial governments*. This was included considering the collective nature of welfare resources¹⁸.
- (2) Social services: These cover actions taken by *provincial governments* to offset or to forestall situations in which the well-being of individuals or families is threatened by circumstances beyond their control. Below three measures are components of social services²⁶.
- (3) Social assistance: This consists of transfer payments to help individuals and families maintain a socially acceptable level of earnings. (e.g., the general welfare payments and the refundable tax credits and rebates for disadvantaged individuals or families, family allowance payments and child tax benefits, etc.)²⁶.
- (4) Workers' compensation: Expenditures on administration and for benefits, other than rehabilitation and medical care, related to workers' compensation schemes
- (5) Other social services: Expenditure related to the services to any other needy individuals or families

References to data series and variables for government expenditure appear in Appendix Table 3.1.

Analyses

The data are analyzed by random-intercept models, with individuals nested within 10 provinces and treated the slopes of individual variables as fixed to estimate the effects of compositional and contextual factors and cross-level interactions. We calculated the

variance partition coefficients (VPC, i.e., intra-class correlation) to present the general contextual effects²⁷.

Models were built in a sequential fashion. We initially included only provincial random effects to model between-province variation in suicide (model 1). Then, in model 2, we added individual-level variables to examine compositional effects in addition to provincial random effects. In model 3, we ran full models with provincial expenditure variables and the cross-level interaction terms between an individual-level variable (non-employed) and a provincial-level variable (expenditure). Since previous studies demonstrate that interaction effects in nonlinear models cannot be properly measured with coefficients and odds ratios of product terms, we calculated average marginal effects (AMEs), which are the averages of predicted marginal effects for every observation in the data²⁸. We conducted statistical significance tests for the produced marginal effects, and then performed second difference tests between the employed and non-employed to capture whether the first differences were equal²⁸. We also tested three-way interactions with gender for model 3, to confirm whether the impacts of social expenditure on inequalities in suicide mortality are different for women and men.

Additionally, two sensitivity analyses were conducted. Firstly, we took the simplest form of a fixed-effects model analysis—a specification in which each cluster was given a fixed intercept by adding nine dummy variables for the ten provinces with the cross-level interaction term²⁹. This was done to show that the results of the random-intercept model were reliable despite concerns over possible biased estimates due to the small number of provinces and omitted time-invariant confounders at the upper level^{29,30} (Appendix Table 3.2). Also, we conducted the same analyses as described above, but replaced the simple

social expenditure share of provincial GDP with one divided by the dependency ratios calculated by estimating the rate between all employed individuals and the total population in each province, since previous studies that adopted a spending approach to measure welfare generosity have been criticized on the grounds that simple figures of expenditure merely reflect levels of welfare need²⁵. The results of the sensitivity analyses are attached in appneix Table 3.3 and 3.4. All analyses were conducted with Stata V.14 (Stata corporation, College Station, Texas, USA).

Results

Table 2.1 presents how many people died by suicide during the period 1991-2011 across Canadian provinces, stratified by employment status and for the total population. It is noted that suicide rates substantially vary across provinces, with Newfoundland having the lowest figure at 0.16% and Alberta having the highest at 0.41%. The disparities between the employed and the non-employed are also different in each province.

Appendix Table 3.5 and 3.6 shows descriptive statistics for total government expenditure and social expenditure variables as a percentage of provincial GDP, across Canadian provinces. Considerable variability in government expenditures by province is observed, which implies that there is enough political autonomy in each Canadian province to merit examination of the impact of expenditures on suicide.

Scatterplots for the associations between expenditures in percent of provincial GDP and odds ratios between the employed and the non-employed in suicide mortality (adjusting for age and gender) are displayed by province (available in Appendix Table 3.6). The lower social expenditures in percent of GDP are, the higher the disparities between the employed and the non-employed are.

The results of the random-intercept modelling are shown in Table 3.2. In model 1, the VPC is 0.017, implying that 1.7% of the individual variation in suicide is due to differences between provinces (not considering the compositional effects). This may appear small, but compared to the results of previous multilevel research investigating cluster effects on suicide, it is not^{31,32}. Results from model 2 demonstrate that the likelihoods of suicide mortality are larger among men, middle-aged, living in a single status, non-immigrant, aboriginal, less educated, less affluent, and non-employed people.

From model 3 to model 7, we progressively added all the individual variables and an expenditure variable with a cross-level interaction term between employment status and social expenditure, one by one. The results show no evidence of an association between expenditures in percent of provincial GDP and suicide mortality. Although most of the coefficients shown in expenditures are negative, their standard errors are too big to generate statistical significance. This is probably attributable to multicollinearity, which can affect standard errors, and the possible cross-over interaction between employment status and expenditures. Meanwhile, the coefficients of the product terms between expenditures and non-employment status are found negative and statistically significant except other social services.

Table 3.3 shows the AMEs of discrete changes of increases of 1% in each expenditure as percentage of GDP on predicted probabilities of suicide mortality. For the employed, an additional increase in any expenditure of 1% of provincial GDP on average was not associated with decreased predicted probability of suicide mortality (column 2). In contrast, a 1% share increase in total government expenditure and social assistance was correlated with decreased probabilities of suicide mortality among the non-employed (column 3). Social assistance expenditure shows the biggest impacts: a 1% share increase in expenditure was associated with 132 hypothetical fewer deaths per 100,000 on average. Interaction tests for detecting the differences in AMEs between the employed and non-employed (column 4) also substantiated that the effects of expenditure differ by employment status. Figure 3.1 and 3.2 visually present analysis of changes in the predicted probabilities of suicide mortality with marginal changes in total and social assistance expenditures in percent of provincial GDP.

Comparison of the sensitivity analyses with need-adjusted expenditure variables (i.e. expenditure in percent of GDP divided on need) showed moderating impacts not only from total and social assistance expenditures, but from other social services and workers' compensation expenditure as well. Finally, we conducted the same analyses for men and women, separately. The results were similar, but the coefficients were slightly higher among women for most models, which may imply that the predictors have greater explanatory power for women. However, three-way interaction tests did not show any statistical significance for gender difference.

Discussion

This study aimed to investigate whether the generosity of social policy measured via provincial social expenditure has protective impacts on overall suicide mortality and/or moderation impacts on the association between individuals' employment status and suicide risk. Our findings showed that the main effects of all the expenditure variables are not associated with lower risks of suicide for Canadians, but that that more expenditures in social assistance and total government spending is associated with lower employment-related inequalities in suicide mortality. Lastly, the effects of welfare generosity turned out to be greater among women, but no gender interaction was detected in our analyses.

While previous micro-macro analyses have investigated the effects of welfare generosity on health in relation to individual-level socioeconomic positions, few studies have tested the effects on so-called "hard outcomes". To our knowledge, this study is the first to address the relationship between welfare generosity and inequalities in suicide mortality within a multilevel framework. By exploiting the advantages of multilevel modelling linked to individual-level data after adjusting for individual predictors, we find that provincial welfare generosity was associated with lower suicide mortality among those marginalized in labour market, after controlling for individual-level factors at baseline.

This study has some limitations. First, since individual-level factors were measured only at the baseline, it is possible that employment status changed during the follow-up period and that such changes affected the outcome. Second, we cannot confirm, with the baseline information, whether a resident in a certain province maintained residence there during the follow-up years. Third, due to the nature of the cross-sectional design, key

time-varying independent variables such as mental health status, socioeconomic positions, and changing trends in welfare generosity were not controlled, making causal inference impossible. Fourth, since we adopted the expense approach to measuring welfare generosity, specific qualities of social policy were not considered, which may prevent our study from illuminating the detailed mechanisms leading to suicide. Lastly, while we confirmed the role of aggregate provincial welfare generosity on the inequality, we know little about the effects of actual receipts of social programs on individuals' suicide risks.

Although our findings are aligned with the findings from recent panel-data studies on the relationship between social protection measures and suicide mortality at the population-level^{17,33}, they contradict previous studies examining associations between suicide deaths and the receipt of social benefits including unemployment insurance and pensions at the individual-level. These social benefits turned out to be associated with *increased* risks of suicide^{34,35}. There are two possible explanations of these contrasting findings. The first possibility is that due to the strong selection bias caused by the stringent criteria for receiving social benefits, the recipients simply represent the most deprived part of the population, although generous social policy still has protective effects for them¹⁶. Thus, if we can successfully suppress the possible endogeneity by methodological means, it may be possible to find the net effects of social benefits. The second possibility is that there may be a certain threshold at which social benefits are effective, and benefits below the threshold may not work at all to address suicide risks³⁵. Especially given that there has been severe retrenchment policies in social welfare policy in many high-income countries since the 1980s, it is plausible that the current level of

income supplement may not be enough to have sufficient efficacy. These possibilities are not mutually exclusive and need to be addressed in future research.

Although the AMEs of total government spending (15 hypothetical fewer suicides per 100,000) and social assistance spending on suicide (132 hypothetical fewer suicides per 100,000) may seem small, the hypothetical reduction in predicted probabilities of suicide mortality among the non-employed after accounting for higher spending, was similar to the predicted probability of suicide mortality before accounting for higher spending. More importantly, enhancing the generosity of social policy is an intervention that can tackle the so-called fundamental causes³⁶, of health inequalities with less stigma, as opposed to interventions that only target high risk populations (such as providing more individualized care for psychiatric patients). More generous social programs have the potential to improve other health outcomes that are known to be affected by socioeconomic resources, beyond having impacts on suicide inequalities¹⁸.

Overall, our analyses found that devoting a larger share of provincial GDP to social assistance and general government spending was associated with lower employment-based inequalities. Different operationalization of welfare generosity, such as need-adjusted social expenditure, corroborates the findings. However, since the relationship is cross-sectional, more micro-macro studies using time-varying individual- and national-/subnational-level variables are required to clarify the relationship between increased welfare generosity and its subsequent effects on suicide and socioeconomic inequalities in suicide.

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TABLES

Table 3.1. Characteristics of Suicide Deaths (suicide plus undetermined deaths), by

Employment Status across Canadian Provinces

Province	Employed	Non-Employed	Total population	p-Value
Newfoundland	0.181	0.127	0.160	<.01
PEI*	0.404	0.274	0.375	0.11
Nova Scotia	0.253	0.292	0.263	<.05
New Brunswick	0.311	0.386	0.332	<.01
Quebec	0.363	0.482	0.393	<.001
Ontario	0.216	0.340	0.238	<.001
Manitoba	0.250	0.432	0.284	<.001
Saskatchewan	0.235	0.312	0.248	<.001
Alberta	0.375	0.586	0.409	<.001
British Columbia	0.219	0.353	0.246	<.001

PEI: Prince Edward Island. Results were weighted, using compw5, as suggested.

Table 3.2. Associations between measures of social expenditure in percent of provincial GDP and suicide mortality. Results of multilevel random-intercept analyses (logit coefficients)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Fixed Effects							
Intercept	- 5.83***	- 9.11***	- 8.70***	- 9.28***	- 8.83***	- 9.12***	- 9.05***
Age							
(continuous)		0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)
Age2							
(continuous)		0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Gender (ref: female)							
Male		1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)
Living arrangement (ref: non-single)							
Single		0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)
Migration status (ref: non-immigrant)							
Immigrant		0.44*** (0.04)	0.44*** (0.04)	0.44*** (0.04)	0.44*** (0.04)	0.44*** (0.04)	0.44*** (0.04)
Aboriginal status (ref: non-aboriginal)							
Aboriginal		0.32*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.31*** (0.05)	0.31*** (0.05)
Education (ref: post-secondary)							
Primary		0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)
Lower secondary		0.48*** (0.04)	0.47*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)
Upper secondary		0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)
Income							
(continuous)		0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.04*** (0.01)
Employment (ref: employed)							
Non-employed		0.53*** (0.03)	1.30*** (0.16)	0.76*** (0.08)	0.99*** (0.13)	0.87*** (0.12)	0.89*** (0.11)
Expenditure (continuous)			-0.01	-0.04	-0.18	-0.00	-0.04

			(0.02)	(0.08)	(0.25)	(0.85)	(0.30)
Interaction term							
Non-employed*			-	-0.05**	-	-	-
Expenditure			0.03*** (0.57)	(0.02)	0.28*** (0.08)	0.58*** (0.21)	0.23*** (0.07)
Random parameter							
Intercept	0.058** *	0.073** *	0.058** *	0.072** *	0.063** *	0.074** *	0.072** *
VPC	0.017	0.022	0.017	0.021	0.019	0.022	0.021
Log likelihood	-45092.9	-43410.1	-43397.8	43404.9	-43403.1	-43406.2	-43404.0

Model 1: Intercept only; Model 2: Model 1+individual-level variables; Model 3: Model 2+total government spending; Model 4: Model 2+social services; Model 5: Model 2+social assistance; Model 6: Model 2+workers' compensation; Model 7: Model 2+other social services. Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001, two-tailed tests.

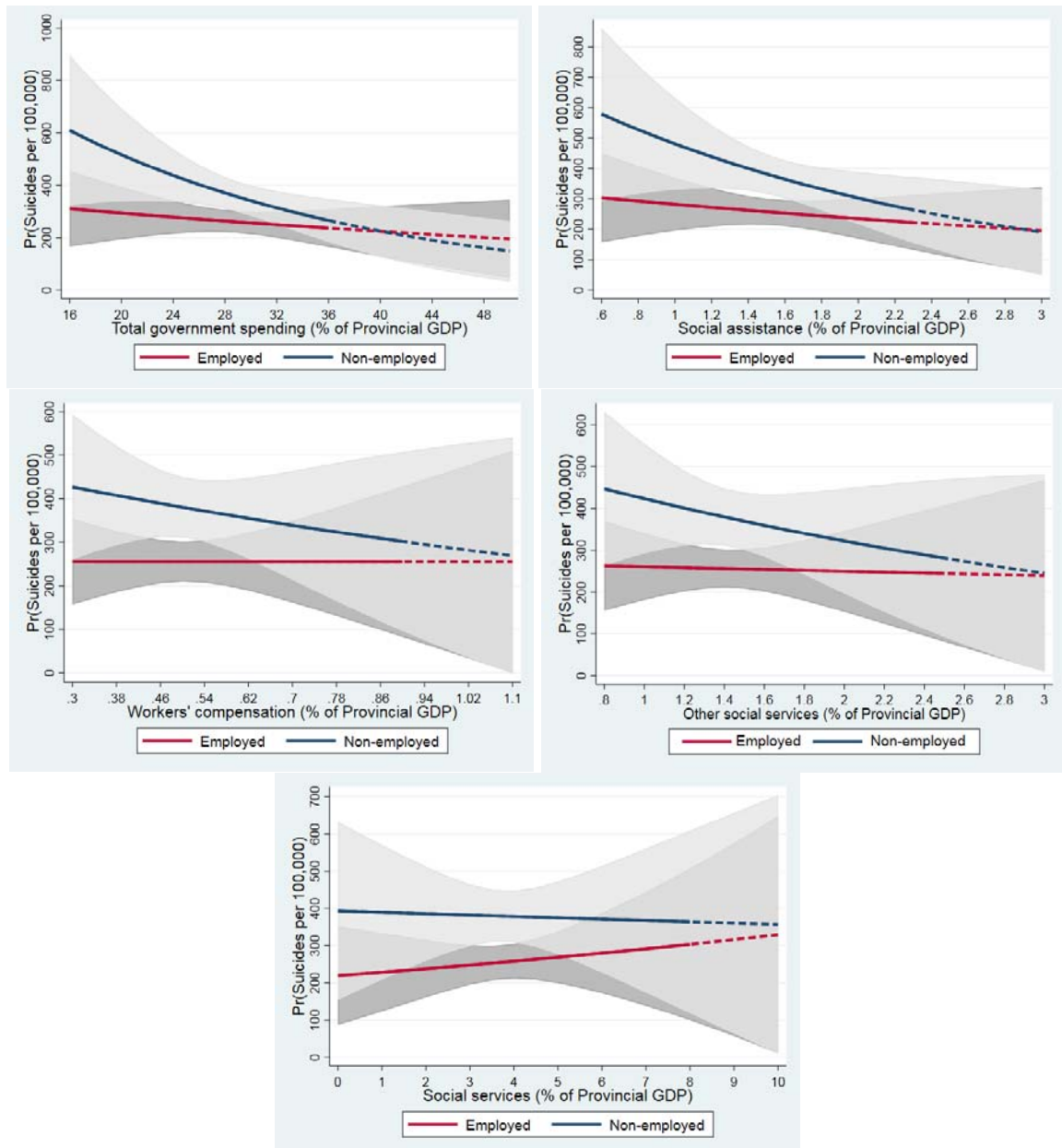
Table 3.3. Average marginal effects (AMEs) of provincial expenditures for the employed and the non-employed and the group difference (second difference) tests per 100,000 people

Provincial Expenditure	AME (Employed)	AME (Non-employed)	Second Differences
Total expenditure	-4 (-7 to -1)	-15* (-21 to -10)	-4-(-15)=11***
Social services	11 (-20 to 42)	-4 (-44 to 36)	11-(-4)=15
Social assistance	-42 (-114 to 29)	-132* (-196 to -69)	-42-(-132)=90***
Other social services	-11 (-128 to 107)	-87 (-209 to 35)	-11-(-87)=76***
Workers' compensation	0 (-398 to 398)	-160 (-449 to 129)	0-(-160)=160*

Notes: 95% confidence intervals are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001, two-tailed tests

FIGURES

Figure 3.1. Predicted probability of suicide rates (per 100,000) by employment status and expenditures: interaction effects between employment status and expenditures



NOTE: Group differences between the employed and non-employed are significant ($p < 0.05$) when lines are solid.

APPENDIX

A3.1. Variable definitions and data sources

The table provides the definitions and the sources of each variable used in the analyses. Data was collected from the Canadian Socio-Economic Information Management System (former) from the following website: <https://www150.statcan.gc.ca/n1/en/type/data?MM=1#tables> (currently Statistics Canada's Trust Centre)

Total expenditures
Includes all provincial expenditures, excluding indicators with missing data (employment pension plan benefits, motor vehicle accident compensations, research establishments, and other expenditures) and indicators with non-service functions (debt charges and general purpose transfers to other government sub-sectors). Total expenditures data is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 10-10-0039-01), series (former): v645252, v645318, v645384, v645450, v645516, v645582, v645648, v645714, v645780, v645846.
Social services
Includes actions taken by provincial governments to offset or to forestall situations where the well-being of individuals or families is threatened by circumstances beyond their control. Social services data is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 10-10-0039-01), series (former): v645269, v645335, v645401, v645467, v645533, v645599, v645665, v645731, v645797, v645863.
Social assistance
Includes expenditures on transfer payments to help individuals and families maintain a socially acceptable level of earnings. Social assistance data is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 10-10-0039-01), series (former): v645270, v645336, v645402, v645468, v645534, v645600, v645666, v645732, v645798, v645864.
Workers' compensation
Includes expenditures on administration and for benefits, other than rehabilitation and medical care, related to workers' compensation schemes. Worker's compensation data is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 10-10-0039-01), series (former): v645271, v645337, v645403, v645469, v645535, v645601, v645667, v645733, v645799, v645865.
Other social services
Includes expenditures related to the provision of services to old age, to persons who are unable to lead a normal life due to a physical or mental impairment, to persons temporarily unable to work due to sickness, to households with dependent children, to persons who are survivors of a deceased person, and to other needy persons. Other social services data is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 10-10-0039-01), series (former): v645274, v645340, v645406, v645472, v645538, v645604, v645670, v645736, v645802, v645868.
GDP per capita
Measures the average income per person for each province, calculated by dividing gross domestic product by population estimates. Data is available from 1990 to 2009 and collected from CANSIM II, Table 3840036, series: v687375, v687409, v687443, v687477, v687511, v687545, v687579, v687613, v687647, v687681.
Dependency ratio
Indicates the proportion of the population that is under 18 and over 65 years of age for each province. Dependency ratio is expressed as the number of dependents for every 100 workers: youth (ages 0 to 17) + seniors (age 65 or older) per 100 workers (aged 18 to 64). Data on the

population over 65 is available from 1990 to 2009 and collected from CANSIM II, Table 385-0001 (currently table 17-10-0005-01), series: v467001, v467316, v467631, v467946, v468261, v468576, v468891, v469206, v469521, v469836. Data on the population under 18 is available from 1999 to 2009 and collected from CANSIM II, Table 510-0001, series: v467274, v467589, v467904, v468219, v468534, v468849, v469164, v469479, v469794, v470109.

AS3.2. Results of fixed-effects regression (robust standard error)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Fixed Effects							
Intercept	-6.37***	-8.59***	-8.49***	-8.60***	-8.53***	-8.60***	-8.59***
Age							
(continuous)		0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)
Age ²							
(continuous)		0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Gender							
Male		1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)
Living arrangement							
Single		0.75*** (0.03)	0.75*** (0.04)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)
Migration status							
Immigrant		-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)
Aboriginal status							
Aboriginal		0.32*** (0.05)	0.31*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.31*** (0.05)	0.31*** (0.05)
Education							
Primary		0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)
Lower secondary		0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)
Upper secondary		0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)
Income							
(continuous)		-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)
Employment							
Non-employed		0.53*** (0.03)	1.30*** (0.16)	0.76*** (0.08)	0.99*** (0.13)	0.87*** (0.12)	0.89*** (0.11)
Provinces							
PEI	0.74***	0.90***	0.86***	0.90***	0.84***	0.90***	0.88***
Nova Scotia	0.45**	0.57***	0.51***	0.57***	0.52***	0.57***	0.55***
New Brunswick	0.69***	0.78***	0.73***	0.77***	0.71***	0.78***	0.76***
Quebec	0.83***	0.95***	0.90***	1.01***	0.93***	1.00***	0.99***
Ontario	0.34**	0.64***	0.52***	0.64***	0.60***	0.66***	0.63***
Manitoba	0.56***	0.66***	0.55***	0.66***	0.62***	0.64***	0.67***
Saskatchewan	0.41**	0.49***	0.41**	0.48***	0.39**	0.49***	0.48***
Alberta	0.90***	1.11***	0.96***	1.10***	1.01***	1.09***	1.08***
British Columbia	0.39**	0.61***	0.50***	0.61***	0.54***	0.64***	0.60***
Interaction term							
Non-employed* Expenditure			-0.03*** (0.57)	-0.05** (0.02)	-0.28*** (0.08)	-0.58** (0.21)	-0.23*** (0.07)

R ²	0.004	0.042	0.042	0.042	0.042	0.042	0.042
Log likelihood	-45072.8	-43388.7	-43377.8	-43383.6	-43382.5	-43384.8	-43382.7

Model 1: Intercept only; Model 2: Model 1+individual-level variables; Model 3: Model 2+total government spending; Model 4: Model 2+social services; Model 5: Model 2+social assistance; Model 6: Model 2+workers' compensation; Model 7: Model 2+other social services. Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001, two-tailed tests.

A3.3. Results of sensitivity analyses: multilevel logistic regression with need-adjusted expenditures

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Fixed Effects							
Intercept	-5.83***	-9.11***	-8.86***	-9.03***	-8.83***	-8.76***	-8.76***
Age							
(continuous)		0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)	0.07*** (0.01)
Age2							
(continuous)		0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Gender							
Male		1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)	1.20*** (0.03)
Living arrangement							
Single		0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)
Migration status							
Immigrant		-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)	-0.44*** (0.04)
Aboriginal status							
Aboriginal		0.32*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.30*** (0.05)	0.31*** (0.05)
Education							
Primary		0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)	0.62*** (0.05)
Lower secondary		0.48*** (0.04)	0.47*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)	0.48*** (0.04)
Upper secondary		0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)	0.25*** (0.05)
Income							
(continuous)		-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.04*** (0.01)
Employment							
Non-employed		0.53*** (0.03)	1.13*** (0.12)	0.81*** (0.08)	1.05*** (0.12)	1.01*** (0.12)	0.96*** (0.10)
Expenditure							
(continuous)			-0.01 (0.01)	-0.02 (0.06)	-0.14 (0.12)	-0.00 (0.85)	-0.04 (0.30)
Interaction term							
Non-employed* Expenditure			-0.02*** (0.00)	-0.05** (0.01)	-0.27*** (0.06)	-0.71*** (0.17)	-0.23*** (0.05)
Random parameter							
Intercept	0.058***	0.073***	0.048***	0.070***	0.049***	0.059***	0.058***
VPC or ICC	0.017	0.022	0.014	0.021	0.014	0.022	0.021
Log likelihood	-45092.9	-43410.1	-43395.6	43402.4	-43398.0	-43400.8	-43399.5

Model 1: Intercept only; Model 2: Model 1+individual-level variables; Model 3: Model 2+total government spending; Model 4: Model 2+social services; Model 5: Model 2+social assistance; Model 6: Model 2+workers' compensation; Model 7: Model 2+other social services. Standard errors are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001, two-tailed tests.

A3.4. Results of sensitivity analyses: average marginal effects (AMEs) of need-adjusted provincial expenditures for the employed and the non-employed and the group difference (second difference) tests per 100,000 people

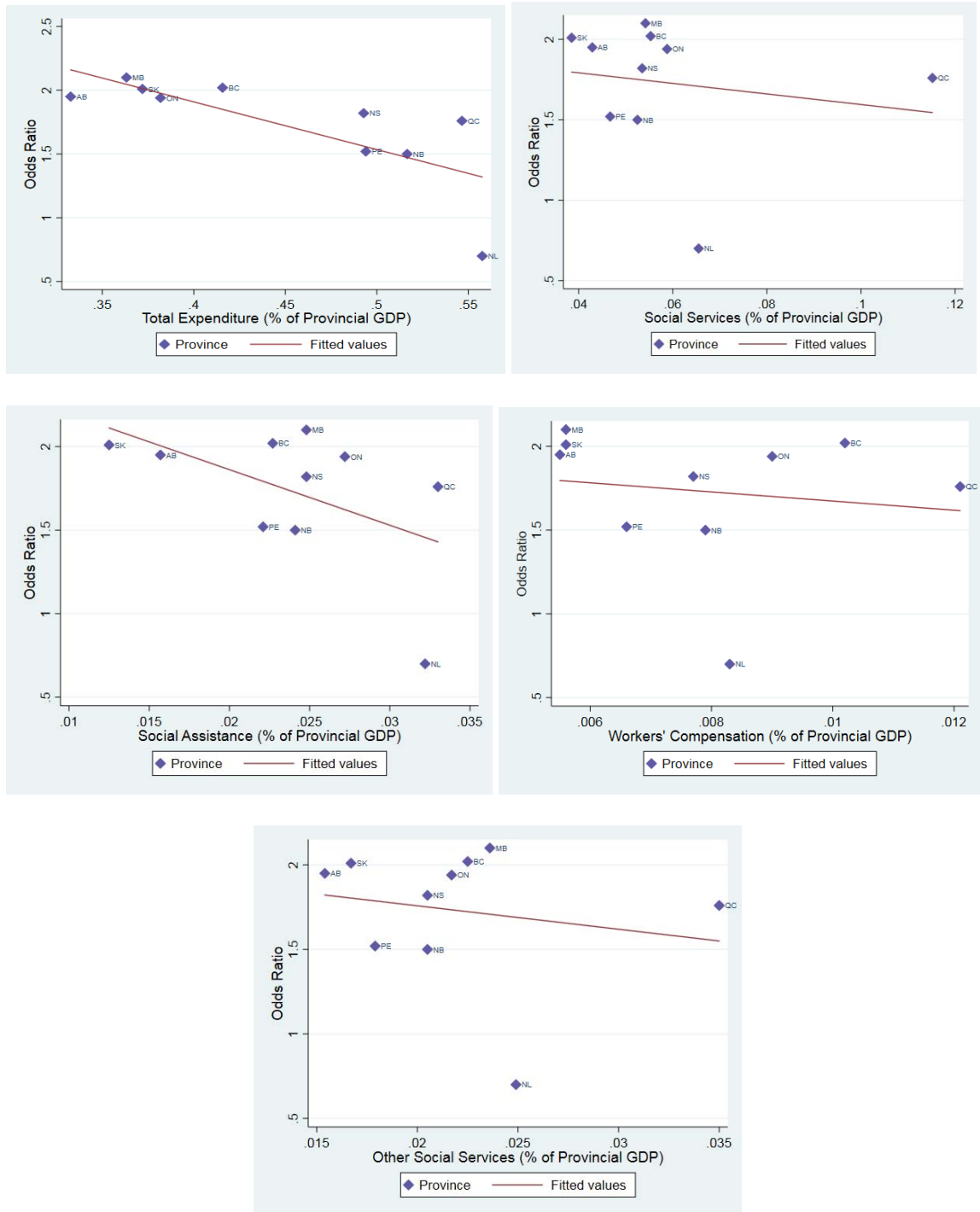
Provincial Expenditure	AME (Employed)	AME (Non-employed)	Second Differences
Total expenditure	-2 (-4 to 0)	-9** (-13 to -6)	-2-(-9)=7**
Social services	-4 (-14 to 6)	-24 (-38 to -10)	-4-(-24)=20***
Social assistance	-33 (-52 to -14)	-122*** (-132 to -111)	-33-(-122)=89***
Other social services	-45 (-80 to -10)	-126** (-157 to -94)	-45-(-126)=81***
Workers' compensation	-107 (-232 to 19)	-257*** (-317 to -197)	-107-(-257)=99***

Notes: 95% confidence intervals are in parentheses. *p < 0.05, **p < 0.01, ***p < 0.001, two-tailed tests.

A3.5. Expenditures as share of total provincial GDP on average (% , 1989-2009)

Province	Total Expenditure	Social Services	Social Assistance	Workers' Compensation	Other Social Services
Newfoundland	34.40	4.04	3.22	0.83	2.49
PEI	34.58	3.27	2.21	0.66	1.79
Nova Scotia	31.10	3.37	2.48	0.77	2.05
New Brunswick	32.29	3.28	2.41	0.79	2.05
Quebec	32.46	6.84	3.30	1.21	3.50
Ontario	23.79	3.66	2.72	0.90	2.17
Manitoba	25.83	3.85	2.48	0.56	2.36
Saskatchewan	29.08	3.01	1.25	0.56	1.67
Alberta	20.63	2.66	1.57	0.55	1.54
British Columbia	25.48	3.39	1.39	1.02	2.25

A3.6. Associations between measures of expenditures and odds ratios between the employed and non-employed in suicide mortality after adjusting for age and gender



CHAPTER 4

STUDY 3: IMPACTS OF OLD-AGE INCOME SECURITY PROGRAM REFORMS ON SUICIDE MORTALITY IN SOUTH KOREA: CONTROLLED INTERRUPTED TIME-SERIES (CITS) ANALYSIS

Abstract

Background: What is the effect of poverty reduction interventions on suicide? There has been little research evaluating the effects of income security programs targeted at older adults (aged 65+) on suicide mortality. In this study, we investigated the effects of two social pension reforms targeting older adults—Basic Old Age Pension (BOAP) and Basic Pension (BP)—implemented in South Korea on suicide mortality.

Design: We conducted controlled interrupted time series (CITS) analyses with negative binomial regression to estimate the effects of both pension reforms by using exogenous variations in the eligibility and the proportions of beneficiaries.

Outcomes: We used monthly rates of suicide and undetermined deaths (UDs) obtained from Statistics Korea (2004-2018) and the Ministry of Interior and Safety.

Participants: A total of 55,999 suicides and 18,327 UDUs among those aged 65+ in 2004-2018 were identified. We introduced two types of control groups: age-based control (comparing older populations with those aged 55-64) and province-based controls (comparing older adults residing in Jeolla-South province that has the highest proportion of beneficiaries to older adults residing in Seoul that has the lowest proportion of beneficiaries).

Results: In the CITS using age-based controls, the BOAP did not lead to significant reductions in suicides and UDs for older men and women while the BP was associated with a reduction in suicides and UDs among older women by 23.7% (equivalent to 2,185 fewer deaths for Korea as a whole) among women, compared to the controls in the post-intervention period. In the CITS using province-based controls, the BP was followed by a 42% (equivalent to 600 additional deaths in the poorest region of Jeolla-South alone) reduction in suicides and UDs in males and a 63% (equivalent to 743 additional deaths in the same region) reduction in females.

Conclusion: Substantial reductions in suicides and UDs for older populations, especially older women, were found since the implementation of social pensions. Our findings indicate that generous and comprehensive income security programs covering older populations in poverty may be an effective policy option to reduce elderly suicide. The findings have particular implications for the low- and middle-income countries in the nascent stage of welfare states since non-contributory pensions are more prevalent in these countries.

Introduction

Case and Deaton noted a shocking fall of life expectancy among the US population as a whole, and surges in “deaths of despair¹”—alcohol, drugs, and suicide—among middle-aged white non-Hispanic Americans with a high school education or less attributable to the fall. After their work was released, the US Centers for Disease and Control and Prevention listed “strengthen economic supports” as the first item in its national core set of strategies to reduce suicide. In fact, studies of the association between socioeconomic position and suicide were well-established in the international contexts even before their work². Nevertheless, relatively little research has been done on whether social and welfare policies that may affect socioeconomic position, and moderate the association with suicide, has been conducted, as well³.

Of the few published studies that have examined social policies, many of them have addressed labour market policies or interventions. For example, studies found the moderating effect of active labour market program and generous unemployment insurance on the association between unemployment rate and suicide mortality^{4,5}. Recently, a growing body of research⁶⁻⁸ in the United States has focused on the role of increasing minimum wage in reducing suicide mortality. Meanwhile, in the low- and middle-income countries, a large-scale field experiment provided evidence that conditional cash transfer programs were associated with reductions in the age-adjusted suicide mortality rate by 0.36 per 100,000 people per year in Indonesia⁹.

These studies have targeted working-age or the total population, and to date no study has been published on suicide among older adults and income security programs targeted for them. Income security programs for older adults have the potential to reduce suicide

by eliminating or reducing the depth of poverty and improving well-being - of older adults, thereby resulting in better mental health^{10,11}. To address the impact of income security programs on health, we undertook a quasi-experimental study to examine whether income supplement programs targeting older adults are associated with reductions suicide mortality. We focused on South Korea, a country with the highest elderly poverty and suicide rates among high-income countries, that had recent social pension reforms for older adults.

Interventions

Traditionally in Korean society, families and adult children had the primary responsibility to financially support their older family members. However, the erosion of the extended family, along with the financial crisis that swept the country in the late 1990s and underdevelopment of public pension programs, has led to widespread poverty among the population of older adults^{10,12}. Poverty among older adults is highly prevalent in Korea, as shown from the fact that 48% of older adults were below the relative poverty line (defined as less than half the median income of the country) in 2014 and the figure has never fallen below 40% since 2000. Although the National Basic Livelihood Security (NBLS) —a means-tested public assistance program launched in 2000—provides financial support to older adults in the bottom 6-7% of the income distribution, approximately 40% of older adults, who were not eligible for the NBLS, are still below the poverty line. To address the widespread poverty of older adults, the Korean government launched the Basic Old-Age Pension (BOAP) in January 2008 for those aged 70 or over and extended it to those aged 65 or over in July 2008. The BOAP is a social pension, “a form of public transfer to older persons, financed not by participants’

contribution but by tax revenue,” to guarantee a subsistence income. Although there was a previous version—the Old Age-Allowance (OAA) —the BOAP is distinct from its predecessor because it covers more than two-thirds of all older adults in the country, while the OAA benefits were given to only 5-20% of the target population (Table 1)^{14,15}. The maximum monthly benefit of the BOAP was 5% of the average monthly pension income earned by the National Pension (NP) beneficiaries, which is equivalent to 84,000 KRW (about USD 84) for singles (5.5% of the per-capita net disposable income in 2008¹⁶). However, despite the introduction of the BOAP, the effects of poverty alleviation were small in magnitude and the relative poverty rates continued to increase between 2008 and 2013¹³. In that year, and as a response to that dismal result, the BOAP was replaced with the Basic Pension (BP) by the newly elected administration and began to be implemented in July 2014 for those aged 65+¹⁵. The BP kept the eligibility requirements for age and income of the BOAP, but doubled the level of benefits: 168,000 KRW (about USD 168) for singles, which is equivalent to 9.8% of the per-capita net disposable income in 2014¹⁶. Detailed institutional background and information about both reforms are available in previous literature^{10,17,18}.

A growing body of research has shown that these two programs (and especially the BP) reduced poverty, and improved the overall financial well-being among older adults in South Korea^{10,17}. However, despite a possible causal connection between poverty and elderly suicide, no study to date has been conducted to examine the impacts of these pension programs on suicide.

Methods

Data

The MicroData Integrated Service (MDIS) provides a national internet-based data repository of South Korean coronial cases¹⁹. We obtained suicide deaths coded X60-X84 (intentional self-harm) and Y10-Y34 (undetermined intent death, UD) with an International Classification of Diseases (ICD), the tenth revision from 1997 to 2018 from the MDIS website. Within this period, there were 270,402 suicides and 44,735 UDs among all population and 69,828 suicides and 21,818 UDs among those aged 65+. Monthly rates of suicides and UDs per 100,000 were calculated using the annual population data (collected in July) disaggregated by age groups and sex and sliding scales of population size between the two consecutive July²⁰. Ethical review is not required for this study since the data is anonymized and publicly available.

Study design

We conducted a series of controlled interrupted time series regressions to examine the effects of the BOAP and BP on rates of suicide and UDs. We carried out Joinpoint Regression analyses (appendix 4.1) for the rate of suicides and UDs among those aged 65+ for the BP) during 1997-2018, with controls by age or by region. We used the Joinpoint technique because the slopes of the time series for the intervention and the control groups should be parallel in the pre-intervention periods for the BOAP and BP to predict the counterfactual. Based on the regression results, we chose the years 2004-2010 and 2010-2018 as study periods for the CITS. A total of 55,999 suicides and 18,327 UDs in 2004-2018 among those aged 65+ are used in the analysis.

Treatment and Control group

We used two different types of controls: age-based controls and province-based controls. Since there were age thresholds for both interventions (70+ for the BOAP and 65+ for the BP), we selected those aged 55-64 as a control group, assuming that people just below the target age groups of the policy have similar characteristics, other than the eligibility of the programs. We excluded those aged 65-69 for the BOAP, since this age group was incorporated into the targets of the BOAP 6 months after the BOAP was initiated. Because the assumption that people below the eligibility age are indeed similar and can be used as a credible control can be disputed, we used another type of control, rather a dose-response setting: Using age-sex-province specific rates of suicide and UDs, we additionally introduced province-based control groups by exploiting the variation in the proportion of BP beneficiaries among the elderly across provinces (Appendix Table 4.2): while the richest province had the lowest rates at about 52.7% (Seoul), the poorest province had the highest rates at about 81.1% (Jeolla South) of those aged 65+. Thus, we chose those aged 65+ in Jeolla South as the treatment group and those aged 65+ Seoul as the control group.

Statistical Analyses

We performed separate segmented linear regression analyses of the rates of suicides and UDs to measure the effects of the BOAP and BP. Negative binomial regression models were estimated to account for overdispersion, with total suicides and UDs as the outcome and log populations as offsets. We adapted post-estimation methods established by Linden²¹, to create the following regression model:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z + \beta_5 Z T_t + \beta_6 Z X_t + \beta_7 Z X_t T_t + e_t$$

where Y_t is the suicide rate at each time point t , T_t is the time from the initiation of the study, X_t is a dummy variable indicating the intervention (post-intervention period=1), and Z is a dummy representing the cohort assignment (treatment=1). X_tT_t , ZT_t , ZX_t , and ZX_tT_t are interaction terms among the variables described earlier. β_1 and $\beta_1+\beta_5$ represent the pre-intervention trends (slope in the pre-intervention period) for the control and treatment group, respectively; β_5 , thus, denotes the difference between the control and treatment groups in the slope of the pre-intervention trends. β_6 indicates the difference between treatment and control groups in the intercept immediately after the intervention (an immediate level change). $\beta_1+\beta_3$ and $\beta_1+\beta_3+\beta_5+\beta_7$ represent the post-intervention trend (slope in the post-intervention period) for the control and treatment group, respectively; $\beta_5+\beta_7$ indicates the difference between the control and treatment groups in the slope of the post-intervention trends. β_3 and $\beta_3+\beta_7$ represent the difference in slopes across intervention for the control and treatment group, respectively; and β_7 indicates the difference between treatment and control groups in the slope during the post-intervention period, compared with the difference in the pre-intervention (i.e. Difference-in-differences of slopes, DID). The main coefficients of interest to assess the effect of the interventions are β_6 and $\beta_5+\beta_7$.

A series of sensitivity analyses were performed to check the robustness of the results. First, we compared the results after including key time-varying confounders: the economic recession dummy variable in 2008 and 2009 and the pesticide regulation dummy variable in 2011 and 2012 (Appendix Table 4.3). Adjusting for the pesticide regulation was necessary because evidence indicates that the regulation implemented at the end of November in 2011 was followed by considerable reductions in suicides and

UDs. This is due to the fact that pesticide ingestion was the most common suicide method among older adults in Korea^{22,23}. Second, we repeated the analysis as the Prais-Winsten autoregressive model, to ensure the analysis was not sensitive to functional form (Appendix Table 4.4). Third, we switched study periods to check whether the results are sensitive to cut-off time points, conducting analyses data using 2003-2010/2011-2018, and 2009-2018, instead of 2004-2010/2010-2018 (Appendix Table 4.5). Fourth, we conducted age-specific analyses to see whether the estimates were robust (for the BOAP: 70-80; 80 or over; for the BP: 65-74; 75-84; 85 or over, Appendix Table 4.6). Fifth, since the 2011-2012 pesticide regulation overlapped with the pre-intervention period of the BP and was followed by considerable reductions in suicides and UD, especially in older adults, we repeated the analyses for the outcome of suicides and UD excluding deaths related to the pesticide (X68 and Y18) in the CITS evaluating the BP (Appendix Table 4.7). Sixth, we conducted the CITS relying on yearly summed data given that it may be difficult to accurately evaluate the immediate effects of stimuli (income supplement) on response (suicide) based on monthly data (Appendix Table 4.8). Lastly, region-specific analyses were repeated by changing the treatment group. To check that the trends are not idiosyncratic to Jeolla-South, we changed the treatment group to Gyeongsang-North and Jeolla-North, the second and third highest proportions of the BP beneficiaries, respectively with Seoul as the control group (Appendix Table 4.9).

All analyses were stratified by sex, because it was expected that men and women could react differently to the intervention. Statistical analyses were conducted using Stata 15.0 (Stata Corporation, College Station, Texas).

Results

Figure 1(a) and 1(b) presents the 21-year trends of rates of suicides, undetermined deaths, non-pesticide suicides, and non-pesticide undetermined deaths per 100,000 per year by gender among those aged 65 or over. Rates of suicides and undetermined deaths started to increase from 1997-1998, when the financial crisis swept the country, but the upward trend accelerated in the early 2000s. Rates of suicides plus UD hit the historic record high in the year 2009 and 2011 for women at 70.26 per 100,000 and men at 167 per 100,000, respectively. The time trends of all rates of suicides and UDs and rates attributable to pesticide overall show similar patterns during the periods when the ban of the herbicide paraquat was implemented, especially among women. However, the year 2011 and 2013 showed the increasing trends in male non-pesticide suicide rates, while the total suicide rates decreased.

The results concerning the effects of the BOAP are shown in Table 2 and Figure 2. In both older men and women, a steeper decrease in suicides and UDs was observed among controls in the pre-intervention period, although the difference test was significant among only men. Overall insignificant reductions in suicide rates immediately after the introduction of the BOAP were observed in men and women. In the post-intervention periods, suicide rates and rates of suicides plus UDs increased for both treatment and control groups simultaneously, and no significant difference between them was shown. However, due to the steeper downward trends in the pre-intervention trend, the pre-post increases in suicide rates and rates of suicides plus UDs were greater among controls although the DID in trends were not significant for either men or women. Each of sensitivity analyses were overall aligned with the main results. In the models that

included the key time-varying confounder and used Prais-Winsten autoregressive models, the main effect estimates were consistent with the initial analysis for all outcomes in men and women. The CITS analyses using study periods 2005-2010 showed that for women significant DIDs in trends were reached in suicide rates (IRR: 0.988, CI: 0.984 to 0.998) and rates of suicide plus undetermined deaths among women (IRR: 0.990, CI: 0.982 to 0.999). Age specific analyses also presented that some demographic groups showed significant differences in the intercepts and slopes of the post-intervention, compared to the controls: suicide rates decreased by 15.1% (CI: 0.724 to 0.995), compared to the controls among men aged 70-79 and significant DIDs in trends were observed in women aged 80+ (IRR: 0.991, CI: 0.982 to 0.999).

The results of CITS analyses of the BP using age-based controls (Table 3 and Figure 3) found that the BP was followed by a 0.5% (IRR: 0.995, 95% CI: 0.991 to 1.000) net reduction in rates of suicide plus UDs per month in the post-intervention period in women aged 65 or over, compared to the control groups in the pre-post difference. With respect to suicides, both older men and women showed steeper downward trends than controls in the pre-intervention period, mainly due to the pesticide regulation. The regulation led to a non-significant increase in the pre-post difference test in women (IRR: 1.001, 95% CI: 0.997 to 1.004) and even a significant increase in men (IRR: 1.004, 95% CI: 1.001 to 1.007), respectively, despite significant steeper downward trends in the post-intervention period for both men and women. Meanwhile, UDs declined more in the controls during the pre-intervention period, and steeper downward trends after the intervention shown in the treatment group resulted in the significant and non-significant

reductions in the DID in trends among men (IRR: 0.997, CI: 0.990 to 1.004) and women (IRR: 0.988, CI: 0.976 to 1.000).

Results of sensitivity analyses supported findings of our main analysis. The CITS analyses without pesticide regulation dummies showed the same findings. In Prais-Winsten autoregressive results, although the DID in trends in rates of suicides plus UDs did not reach statistical significance among older women, the results were significant when considering non-pesticide deaths only (-0.01 per 100,000 older women, 95% CI: -0.023 to 0). When the year of 2011 was chosen as the starting year of the study period, instead of 2010, the statistical significance of the DID in trends among women in suicides plus UDs disappeared, but the estimates barely changed (0.996, CI: 0.991 to 1.002). Estimates from models considering only deaths attributable to non-pesticide means were not much different from ones in the main analysis as well, except that the DID in trends among men were slightly greater in women (IRR: 0.994, CI: 0.990 to 0.999). Analyses using yearly data found an immediate impact: there were significant reductions in UDs among both men (-5.51 per capita per year, 95% CI: -11.06 to 0) and women (-4.43 per capita per year, 95% CI: -6.21 to -2.65), and the rate of suicides plus UDs among women (-6.12 per capita per year, 95% CI: -12.15 to -0.10). Results of age specific analyses were aligned with the main findings: 1) immediate reductions were not observed in either men or women, and 2) greater reductions in the post-intervention, compared to the controls, led to the significant DID in trends among only women. The downward trends were especially the greatest among women aged 85 or over (IRR: 0.992, CI: 0.987 to 0.998).

The CITS analyses evaluating the BP comparing older adults in Jeolla-South and Seoul found that men and women aged 65+ in Jeolla-South experienced 1% and 1.8% net reductions (respectively) in rates of suicides plus UDs per month on average, relative to the pre-post difference in older men and women in Seoul (Table 4 and Figure 4). The effect sizes are greater than in ones estimated in the analyses using age-based controls, since reductions in UDs for both men and women were pronounced. The BP was followed by significant reductions in UDs for both men (IRR: 0.973, 95% CI: 0.963 to 0.983) and women (IRR: 0.970, 95% CI: 0.958 to 0.982), compared to the controls, and significant differences in the pre-post trends in controls whereas post-trend differences between controls and treatments were not significant in suicide for both men and women. However, as with the previous approach, we cannot observe the immediate impacts of the BP. Each of the sensitivity analyses were consistent with the results. Changing the outcome to the non-pesticide related suicides and undetermined deaths found even stronger and more consistent policy effects. Analyses changing study periods, using Newey-West estimation, and exploiting monthly data reported very similar findings. The DID in trends did not reach statistical significance, but it showed substantial (albeit not precisely estimated) reductions, and a robustness check using monthly data showed highly significant DID in trends (S17). Lastly, shifting the treatment group to older adults residing in other provinces displayed similar findings. Gyeongsang-North and Jeolla-North, having the second and third highest beneficiary rates, witnessed immediate or/and steady reductions in undetermined mortality, although the effect sizes were smaller than the comparison between older adults in Jeolla-South and Seoul.

Discussion

Using a natural experimental design, we evaluated the policy effects of two social pension reforms on suicide and undetermined intent mortality of older adults in South Korea. We found that the BOAP, which expanded beneficiaries while keeping the benefit level low, did not lead to significant reductions in suicide and undetermined deaths for older populations, immediately after the implementation and in the post-intervention period. However, although it did not reach the statistical significance, the pre-post difference was consistently smaller than controls and some sensitivity analyses reached the significance among women. Meanwhile, the BP, which increased benefits while maintaining the population coverage, significantly reduced deaths from suicides and undetermined deaths. In the CITS analysis using age-based controls, the BP brought about 0.5% (IRR: 0.995, 95% CI: 0.991 to 1.000) additional reductions in suicides plus UDs among women aged 65+ per month on average in the post-intervention periods, which indicates that such a decrease during the post-intervention period would have resulted in approximately 2,150 fewer deaths by suicide and UD (21.38% decrease in total) in women. In the CITS analyses using province-based controls, older men and women in Jeolla-South experienced annual reductions in the pre-post trends compared with those of older men and women in Seoul of 1% (IRR: 0.990, 95% CI: 0.982 to 0.998) and 1.8% (IRR: 0.982, 95% CI: 0.972 to 0.992), respectively, per capita, per month, on average. This corresponds to a reduction in rates of suicides and UDs by 38.3% and 58.2% in total for four years among older men and women, respectively, in Jeolla-South province, compared to older populations in Seoul. The main results were robust to a series of sensitivity analyses, including time-varying confounders, conducting a Prais-

Winsten autoregressive model, changing study periods, considering outcomes without pesticide-related suicides and UDs, using yearly data, changing treatment groups, to repeating sub-group analyses. In the analysis using yearly data, instead of monthly data, an immediate reduction in suicides and UDs, compared to the controls, immediately after the BP introduction was found among women, while the DID in trends were not observed.

Although the BOAP was followed by increases in suicides and UDs, rather than reductions in the post-intervention period, the increases in the pre-post difference were consistently smaller in older women than controls, and their p-values were quite small ($0.05 < \text{p-value} < 0.1$). This pre-post difference in trends between the control treatment group can be interpreted as the policy impacts, given that older women were the same population who showed policy effects in the CITS analyses evaluating the BP. However, we cannot exclude the possibility that the second-difference test can also be attributable to the differential effects of the economic recession. As shown in the sensitivity analyses including the dummies, this time-varying confounder may have different impacts on the control and treatment group. Little research addressed the interaction effects between age and macroeconomic conditions on suicide, yet it is plausible that working-age population is more sensitive to the business cycle than older populations. However, among men, older men witness more increases in suicides and UDs than controls in the post-intervention period. Either way, unfortunately the measured policy effects are inseparable from the effects of the concurrent recession in our analyses.

The finding that doubling the benefit level of non-contributive retirement pensions led to subsequent reductions in suicides and UDs of older adults adds evidence that

income security programs for older populations have policy effects on a reduction in suicide risks among older populations. It therefore suggests that poverty (or uncertainty of income) increases the likelihood of committing suicide among the elderly. Previous studies examining the impacts of labour market policies or conditional cash transfers for working-age population have demonstrated that a US \$1 increase in the minimum wage was followed by a 1.9% decrease in suicide rates per year in the US and cash transfer programs in Indonesia reduced the yearly suicide rates by 18%^{8,9}. The effect sizes reported in this study are larger than the ones in the previous studies, suggesting that poverty or uncertainty of income might be a more potent driver of suicide among older populations than in the rest of the population.

Meanwhile, our findings also contribute to a growing body of research examining the impacts of the pension reforms on different outcomes in South Korea. While other quasi-experimental studies examining the effects of the BOAP or the BP on the material well-beings found positive effects, previous studies about subjective mental health, such as life-satisfaction and depression symptoms have shown inconsistent findings^{17,24}. This discrepancy can be in part explained by the fact that it is not always the case that trends in mental health status should be aligned with the trends in suicide mortality and UDs. This is substantiated by previous studies showing diverging trends of suicide deaths, attempts and ideations¹². Also, even if they should indicate the same trends, it is likely that our estimates are less biased since suicides and UDs are objective outcomes, which is considered more valid and reliable than subjective self-reports of well-being²⁵.

Our findings showed that the effects of the two social pension reforms on suicide were more consistently shown in women than in men. It is convincing, given that that the

majorities of the beneficiaries were women. Previous research examining the impacts of the macroeconomic cycles on suicide and mortality have shown that women might be more sensitive to the economic status than men, due to the clear disadvantages in the labour market^{12,26}. Women have shorter work histories and consequently lower contributions in the labour market, which results in higher needs of the compensatory welfare resources transferred by the state than men, especially in South Korea where women's labour market participation rates have been consistently low. Studies done in other contexts also found that the generous basic security of the pension system is more salutary for women's health outcomes³. Future research needs to address the exact mechanisms to explain the gendered effects of income security interventions on preventing suicide outcomes and improving other health outcomes²⁷.

Since we did not test the policy effects on the individuals who were actual recipients of the benefits, and compare them to the non-recipients, we cannot test whether the two social pension reforms have decreased income-based inequalities in suicides and UDIs among people with different social class. Nevertheless, it is likely that the reductions in suicide were much from poorer populations, resulting in a reduction in inequalities, given that the policy brought about greater effects in age groups and the province with more proportions of beneficiaries. Also, our finding that the BOAP had almost no significant policy effects while the BP had also support the possibility that there is a dose-response relationship between the amount of the benefit and sizes of the reduction in suicide risks, which is likely to bring about reduction in the income-based inequality of suicide.

There are some limitations to our analyses. First, it could be argued that those aged 55-64, who were not eligible for the program, are not an appropriate control group since

each cohort in different age groups) as they may have been affected by different generational experience (i.e., cohort effects) and accordingly the estimated reductions from CITS may not be accurate. This may be an especially salient limitation for South Korea, as older adults had traumatic experiences in their youth, such as going through the Korean war and extreme poverty. Nevertheless, there has been little evidence showing that these experiences were particularly important risk factors for suicide mortality in that generation. In fact, a recent study investigating age-cohort-period effects on patterns of suicide found that suicide patterns including UDs among older adults in Korea is attributable to an age effect, not a cohort effect²⁸. Furthermore, we complemented the results by conducting additional analyses using different controls based on regions, limiting the study population to the same age groups, at least for the BP.

Another limitation is related to the quality of vital statistics on mortality of suicides and UDs. Before 2000, Korean death statistics were considered only moderate in terms of quality by WHO²⁹. Besides, suicide is a stigmatized death; there is some evidence showing that there has been underreporting and misclassification of suicides, due to cultural reasons. However, the study periods in the paper were restricted to the mid 2000s and afterwards, which were considered of high quality. Moreover, although there is systematic underreporting of suicides, the estimates from the CITS analyses are not likely to be biased, unless the underreporting is systematically applied differently to the control and treatment group and across the intervention, which seems unlikely. Lastly, we cannot exclude the possibility that there may be other concurrent events influencing suicide, other than interventions. Especially, in evaluating the BP, although we adjusted for the 2008 recession dummy, we cannot conclude that the insignificant reductions are

attributable to the policy or the differential effects of the recession on the different populations.

Substantial reductions in suicide mortality and UDs for older populations, especially older women, were found since the implementation of social pensions in 2008 in South Korea. Our findings indicate that generous and comprehensive income security programs covering older populations in poverty may be an effective policy option to reduce elderly suicide. The findings have particular implications for the low- and middle-income countries in the nascent stage of welfare states since non-contributory pensions have more prevalent among these countries.

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TABLES

Table 4.1. Transitions in Non-contributory Social pension in South Korea

Year	Program name	Eligibility	Benefit level	Beneficiary rates
January 1991	Old-Age Allowance	70+, Institutionalized Low-income individuals	USD 15 (1994)	5.6%-13.6%
January 1997	Old-Age Allowance	Beneficiaries aged 65+, Social assistance	USD 35~50 ^a	8.5%
July 1998	Old-Age Pension	65+, Those whose income was below KRW 370,000	USD 35~50	13.6%-20.4%
January 2008	Basic Old Age Pension	70+, The bottom 60%	USD 69.5~99 ^b	57.2%
July 2008	Basic Old Age Pension	65+, The bottom 60%		57.2%
January 2009	Basic Old Age Pension	65+, The bottom 70%		65.0-68.9%
July 2014	Basic Pension	65+, The bottom 70%	USD 110~250 ^c	65.8-69.8%

- a. Differential benefits based on the status of social assistance beneficiaries and residence of institutions
- b. 139,000 for a married couple, 84,000 for a single-person, adjusted by the yearly consumer price index, 5% of the average monthly income of the NPS participants, deferential benefits according to Calculated Income (CI)—evaluated income by applying particular equations with business income, asset income, public transfers, Converted Income of Asset, calculated by the sum of the general assets, financial assets, cars, and donated assets of adult children and debt.
- c. 269,000 for a married couple, 168,000 for a single person, adjusted by the yearly consumer price index, 10% of the average monthly income of the insured of the NPS, deferential benefits according to Calculated Income (CI)—evaluated income by applying particular equations with business income, asset income, public transfers, Converted Income of Asset, calculated by the sum of the general assets, financial assets, cars, and donated assets of adult children and debt, as well as wage and housing.

Source: Fiscal Demand Estimation of Basic Pensions from 2018 to 2027¹ (National Assembly Budget Office)

Table 4.2. Segmented negative binomial regression analysis of rates of suicides (ICD-10-Codes: X60-X84) and undetermined deaths (Y10-Y34) by sex using province-based controls to evaluate the BOAP (launched in January 2008)

BOAP (study period: 2004-2010)	X60-X84 (a)		Y10-Y34 (b)	
Measure of interest	Men	Women	Men	Women
Pre-trend (Control): β_1	0.994*** (0.992 to 0.997)	0.995* (0.992 to 0.999)	0.994* (0.990 to 0.999)	1.000 (0.993 to 1.008)
Pre-trend (Treatment): $\beta_1 + \beta_5$	0.999 (0.996 to 1.001)	0.998 (0.995 to 1.002)	1.001 (0.996 to 1.006)	1.001 (0.994 to 1.008)
Pre-trend difference: β_5	1.004* (1.001 to 1.008)	1.003 (0.998 to 1.008)	1.007* (1.000 to 1.013)	1.000 (0.991 to 1.010)
Level difference: β_6	0.859 (0.732 to 1.007)	0.888 (0.721 to 1.092)	1.070 (0.819 to 1.414)	0.979 (0.653 to 1.468)
Post-trend (Control): $\beta_1 + \beta_3$	1.006** (1.002 to 1.010)	1.008** (1.003 to 1.014)	0.994 (0.987 to 1.002)	0.996 (0.985 to 1.007)
Post-trend (Treatment): $\beta_1 + \beta_3 + \beta_5 + \beta_7$	1.007** (1.003 to 1.011)	1.003* (0.998 to 1.009)	0.999 (0.992 to 1.006)	1.000 (0.989 to 1.010)
Post-trend difference: $\beta_5 + \beta_7$	1.001 (0.995 to 1.007)	0.995 (0.988 to 1.003)	1.005 (0.995 to 1.015)	1.004 (0.989 to 1.019)
Pre-post difference (Control): β_3	1.012*** (1.007 to 1.017)	1.013*** (1.006 to 1.019)	1.000 (0.991 to 1.009)	0.995 (0.982 to 1.009)
Pre-post difference (Treatment): $\beta_3 + \beta_7$	1.009** (1.004 to 1.014)	1.005 (0.999 to 1.012)	0.998 (0.990 to 1.007)	0.999 (0.987 to 1.011)
Difference-in-Differences: β_7	0.997 (0.990 to 1.004)	0.993 (0.986 to 1.002)	0.998 (0.986 to 1.011)	1.003 (0.986 to 1.022)

BOAP (study period: 2004-2010)	X60-X84 (a) and Y10-Y34 (b)	
Measure of interest	Men	Women
Pre-trend (Control): β_1	0.994*** (0.992 to 0.997)	0.996* (0.993 to 0.999)
Pre-trend (Treatment): $\beta_1 + \beta_5$	0.999 (0.997 to 1.002)	0.999 (0.996 to 1.002)
Pre-trend difference: β_5	1.005** (1.001 to 1.008)	1.002 (0.998 to 1.007)
Level difference: β_6	0.927 (0.801 to 1.072)	0.932 (0.783 to 1.104)
Post-trend (Control): $\beta_1 + \beta_3$	1.004* (1.000 to 1.008)	1.006** (1.002 to 1.011)
Post-trend (Treatment): $\beta_1 + \beta_3 + \beta_5 + \beta_7$	1.005** (1.001 to 1.009)	1.002 (0.998 to 1.007)
Post-trend difference: $\beta_5 + \beta_7$	1.001 (0.996 to 1.006)	0.996 (0.990 to 1.002)
Pre-post difference (Control): β_3	1.010*** (1.006 to 1.015)	1.010*** (1.005 to 1.016)
Pre-post difference (Treatment): $\beta_3 + \beta_7$	1.006** (1.002 to 1.011)	1.003** (0.998 to 1.009)
Difference-in-Differences: β_7	0.996 (0.990 to 1.003)	0.993 (0.986 to 1.001)

Table 4.3. Segmented negative binomial regression analysis of rates of suicides undetermined deaths by sex using age-based controls to evaluate the BP (launched in July 2014)

BP (study period: 2010-2018)	X60-X84 (a)		Y10-Y34 (b)	
Measure of interest	Men	Women	Men	Women
Pre-trend (Control): β_1	0.997**(0.995 to 0.999)	0.994*** (0.991 to 0.996)	0.994** (0.991 to 0.998)	0.987*** (0.981 to 0.993)
Pre-trend (Treatment): $\beta_1 + \beta_5$	0.993*** (0.991 to 0.995)	0.992*** (0.989 to 0.994)	0.997 (0.993 to 1.000)	0.997 (0.991 to 1.003)
Pre-trend difference: β_5	0.996** (0.993 to 0.999)	0.998 (0.994 to 1.002)	1.002 (0.997 to 1.008)	1.010* (1.001 to 1.019)
Level difference: β_6	1.048 (0.924 to 1.189)	0.987 (0.834 to 1.155)	1.150 (0.924 to 1.433)	1.027 (0.693 to 1.521)
Post-trend (Control): $\beta_1 + \beta_3$	0.998 (0.996 to 1.000)	0.997* (0.995 to 1.000)	0.997 (0.993 to 1.000)	0.995 (0.988 to 1.001)
Post-trend (Treatment): $\beta_1 + \beta_3 + \beta_5 + \beta_7$	0.997** (0.995 to 0.999)	0.993*** (0.990 to 0.995)	0.997* (0.993 to 1.000)	0.993* (0.987 to 0.999)
Post-trend difference: $\beta_5 + \beta_7$	0.999 (0.996 to 1.002)	0.995** (0.992 to 0.999)	1.000 (0.995 to 1.005)	0.998 (0.989 to 1.007)
Pre-post difference (Control): β_3	1.001 (0.998 to 1.004)	1.004 (1.000 to 1.007)	1.002 (0.997 to 1.007)	1.008 (0.998 to 1.017)
Pre-post difference (Treatment): $\beta_3 + \beta_7$	1.004** (1.001 to 1.007)	1.001 (0.997 to 1.004)	1.000 (0.995 to 1.005)	0.996 (0.987 to 1.004)
Difference-in-Differences: β_7	1.003 (0.999 to 1.007)	0.997 (0.992 to 1.002)	0.997 (0.990 to 1.004)	0.988 (0.976 to 1.001)

BP (study period: 2010-2018)	X60-X84 (a) and Y10-Y34 (b)	
Measure of interest	Men	Women
Pre-trend (Control): β_1	0.997*** (0.995 to 0.998)	0.993*** (0.991 to 0.995)
Pre-trend (Treatment): $\beta_1 + \beta_5$	0.995*** (0.992 to 0.996)	0.993*** (0.991 to 0.996)
Pre-trend difference: β_5	0.997* (0.995 to 1.000)	1.000 (0.997 to 1.003)
Level difference: β_6	1.025 (0.918 to 1.144)	0.969 (0.841 to 1.116)
Post-trend (Control): $\beta_1 + \beta_3$	0.998* (0.996 to 1.000)	0.997* (0.995 to 0.999)
Post-trend (Treatment): $\beta_1 + \beta_3 + \beta_5 + \beta_7$	0.997** (0.995 to 0.999)	0.993*** (0.990 to 0.995)
Post-trend difference: $\beta_5 + \beta_7$	0.999 (0.997 to 1.002)	0.995** (0.992 to 0.999)
Pre-post difference (Control): β_3	1.001 (0.999 to 1.004)	1.004* (1.001 to 1.007)
Pre-post difference (Treatment): $\beta_3 + \beta_7$	1.003* (1.001 to 1.006)	0.999 (0.996 to 1.003)
Difference-in-Differences: β_7	1.002 (0.998 to 1.005)	0.995* (0.991 to 1.000)

Table 4.4. Segmented negative binomial regression analysis of rates of suicides undetermined deaths by sex using province-based controls to evaluate the BP (launched in July 2014)

BP (study period: 2010-2010)	X60-X84		Y10-Y34	
Measure of interest	Men	Women	Men	Women
Pre-trend (Control): β_1	0.995*(0.991 to 1.000)	0.994 (0.988 to 1.000)	0.996 (0.989 to 1.003)	0.992 (0.984 to 1.001)
Pre-trend (Treatment): $\beta_1+\beta_5$	0.998 (0.993 to 1.002)	0.998 (0.991 to 1.005)	0.997 (0.990 to 1.004)	0.997 (0.988 to 1.005)
Pre-trend difference: β_5	1.003 (0.996 to 1.009)	1.004 (0.995 to 1.013)	1.001 (0.990 to 1.011)	1.004 (0.992 to 1.017)
Level difference: β_6	0.949 (0.717 to 1.257)	1.029 (0.691 to 1.531)	1.044 (0.667 to 1.632)	0.880 (0.517 to 1.500)
Post-trend (Control): $\beta_1+\beta_3$	0.996*(0.991 to 1.000)	0.993*(0.987 to 0.999)	1.008*** (1.001 to 1.015)	0.999 (0.991 to 1.008)
Post-trend (Treatment): $\beta_1+\beta_3+\beta_5+\beta_7$	0.995*(0.991 to 1.000)	0.988** (0.981 to 0.995)	0.981*** (0.974 to 0.987)	0.969*** (0.961 to 0.978)
Post-trend difference: $\beta_5+\beta_7$	1.000 (0.993 to 1.006)	0.995 (0.986 to 1.004)	0.973* (0.963 to 0.983)	0.970*** (0.958 to 0.982)
Pre-post difference (Control): β_3	1.000 (0.994 to 1.007)	0.999 (0.990 to 1.008)	1.012* (1.002 to 1.023)	1.007 (0.995 to 1.019)
Pre-post difference (Treatment): $\beta_3+\beta_7$	0.998 (0.991 to 1.004)	0.990* (0.981 to 1.000)	0.984** (0.973 to 0.993)	0.973*** (0.961 to 0.985)
Difference-in-Differences: β_7	0.997 (0.988 to 1.006)	0.991 (0.979 to 1.004)	0.972*** (0.958 to 0.986)	0.966*** (0.950 to 0.983)

BP (study period: 2010-2010)	X60-X84 and Y10-Y34 (a) and (b)	
Measure of interest	Men	Men
Pre-trend (Control): β_1	0.995*(0.991 to 0.999)	0.994*(0.988 to 0.999)
Pre-trend (Treatment): $\beta_1+\beta_5$	0.997 (0.993 to 1.001)	0.997 (0.992 to 1.003)
Pre-trend difference: β_5	1.002 (0.996 to 1.007)	1.003 (0.996 to 1.001)
Level difference: β_6	0.938 (0.734 to 1.198)	1.001 (0.994 to 1.009)
Post-trend (Control): $\beta_1+\beta_3$	0.998 (0.994 to 1.002)	0.995 (0.990 to 1.000)
Post-trend (Treatment): $\beta_1+\beta_3+\beta_5+\beta_7$	0.990*** (0.987 to 0.994)	0.980*** (0.990 to 1.000)
Post-trend difference: $\beta_5+\beta_7$	0.992** (0.987 to 0.998)	0.985*** (0.978 to 0.993)
Pre-post difference (Control): β_3	1.003 (0.997 to 1.008)	1.001 (0.994 to 1.009)
Pre-post difference (Treatment): $\beta_3+\beta_7$	0.993* (0.988 to 0.999)	0.983*** (0.976 to 0.991)
Difference-in-Differences: β_7	0.990* (0.982 to 0.998)	0.982** (0.972 to 0.993)

FIGURES

Figure 4.1A-B. Crude mortality rates of suicide, non-pesticide suicide, undetermined death, and non-pesticide undetermined death among men and women aged 65+, 1997-2018 (men: left; women: right)

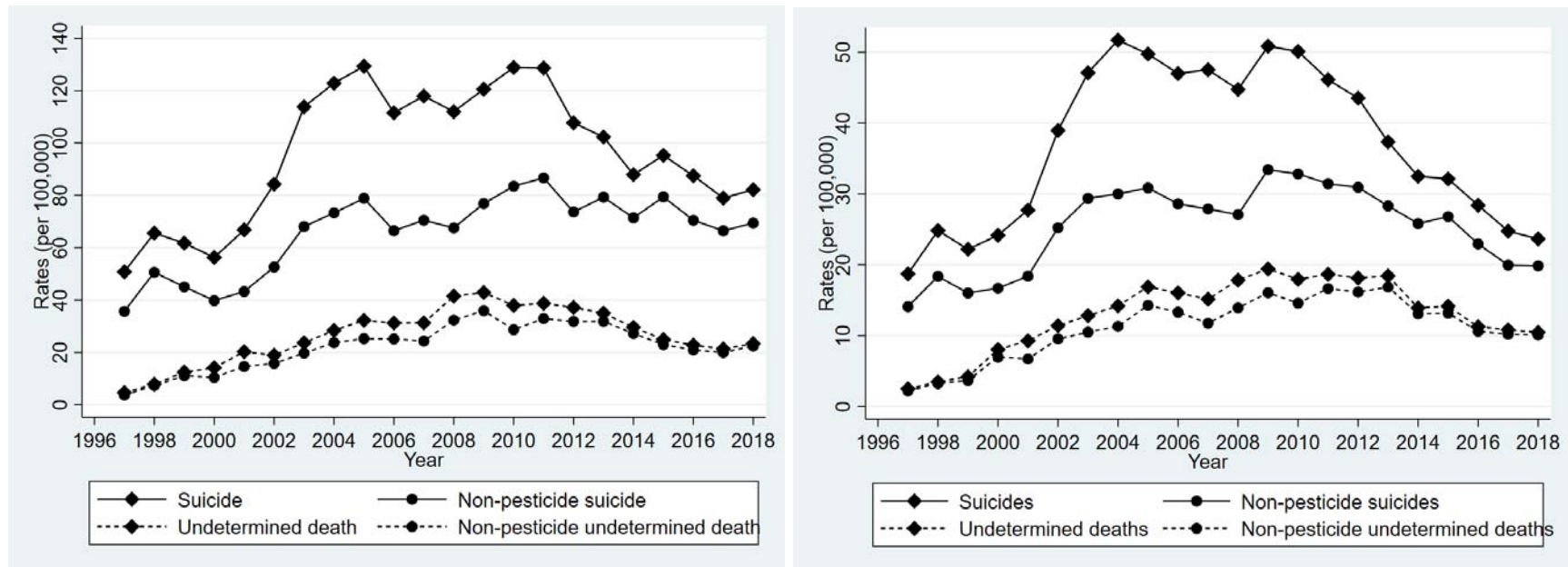
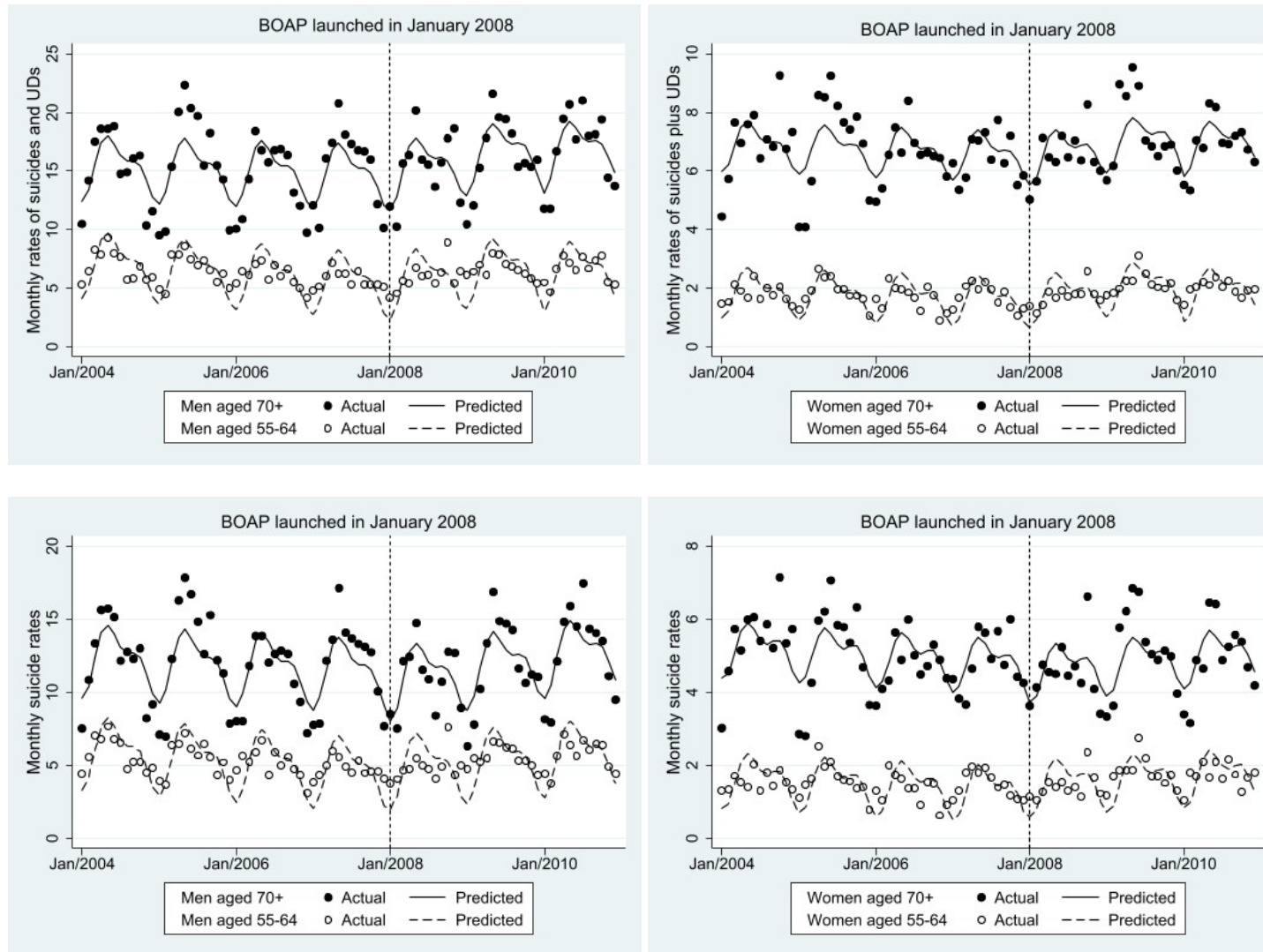


Figure 4.2A-F. CITS using age-based control for the BOAP: suicide rates and rates of undetermined deaths



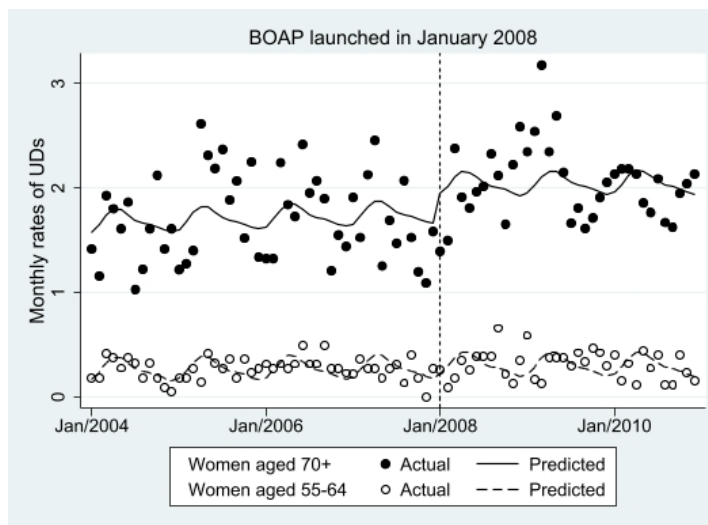
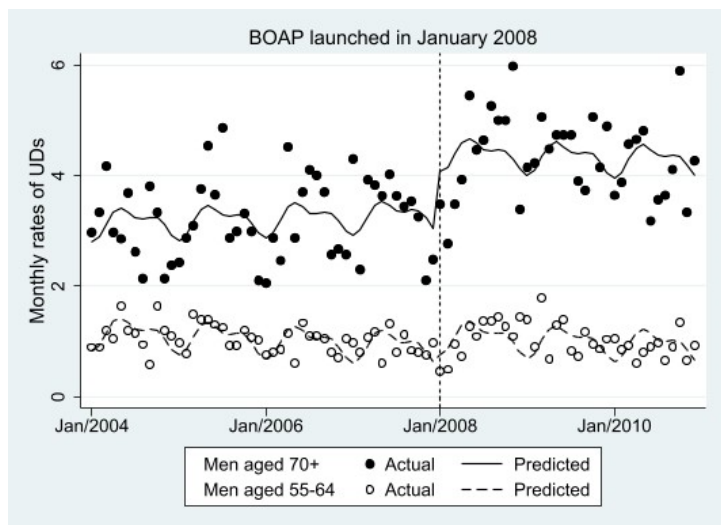
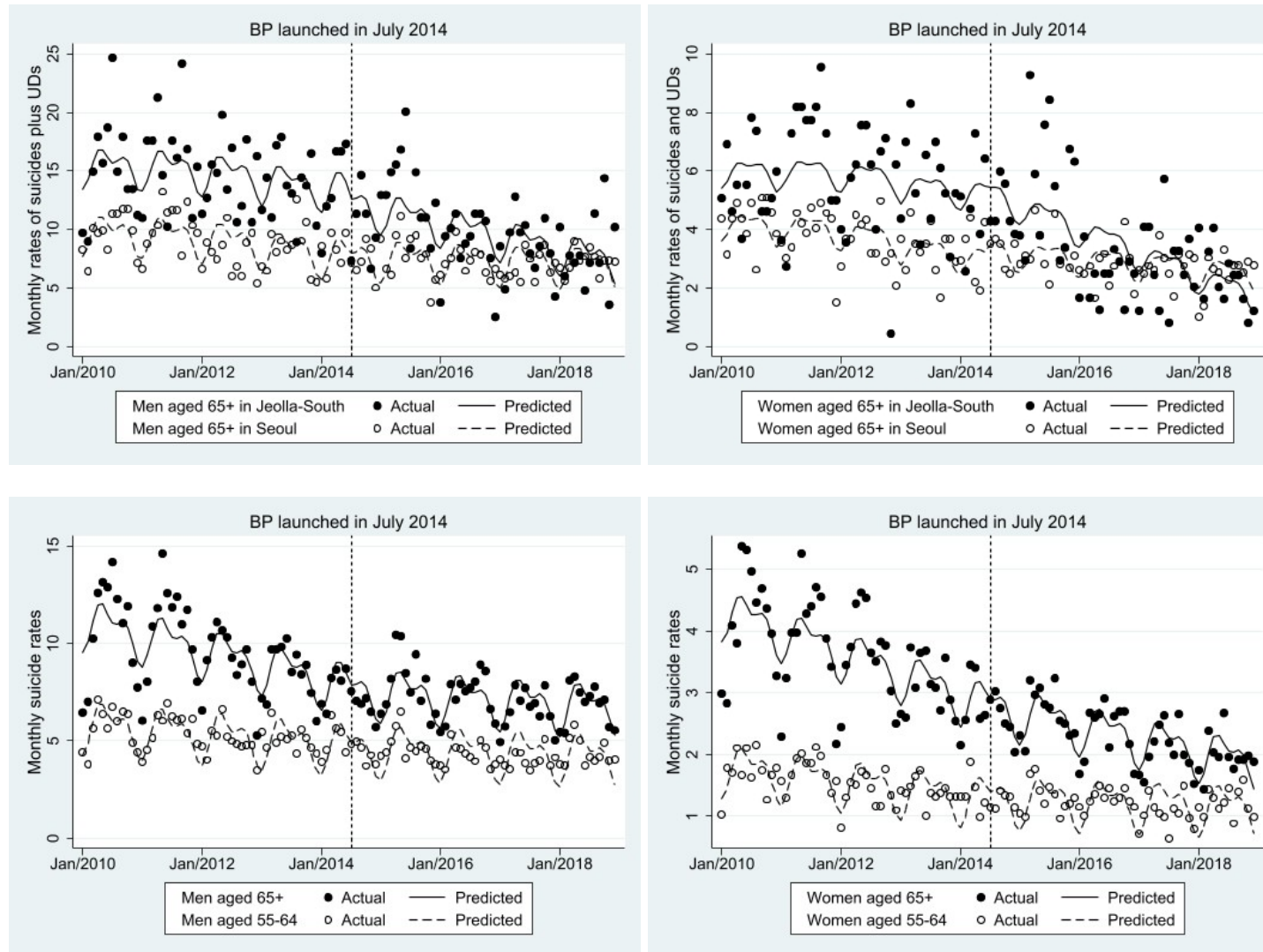


Figure 4.3A-F. CITS using age-based control for the BP: suicide rates and rates of undetermined deaths



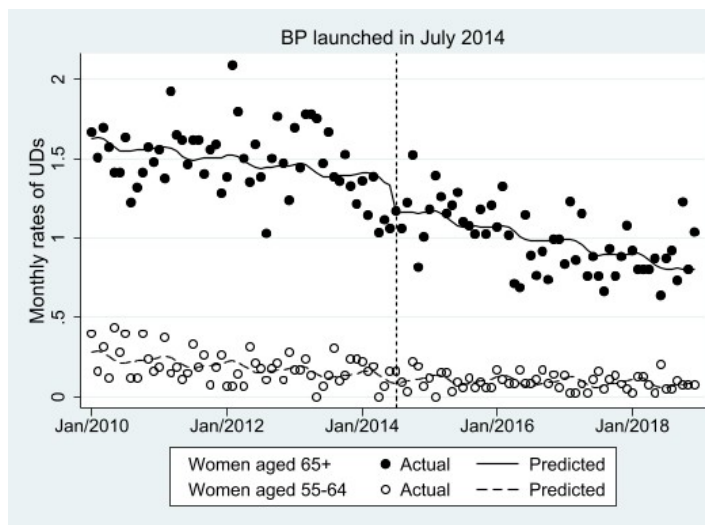
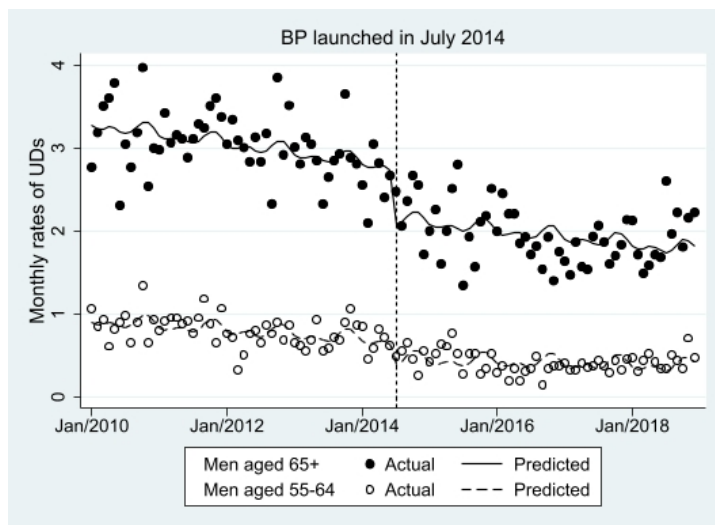
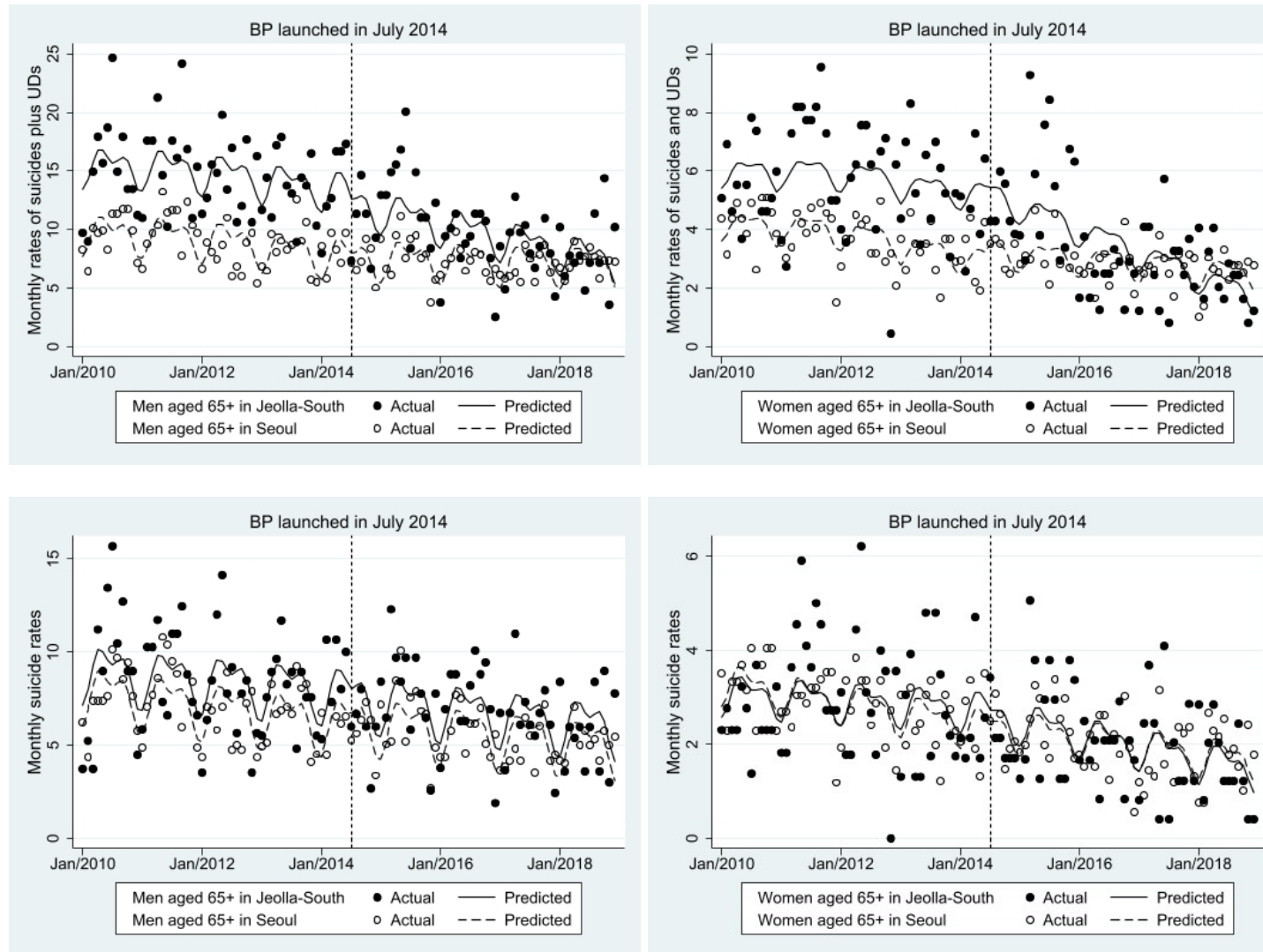
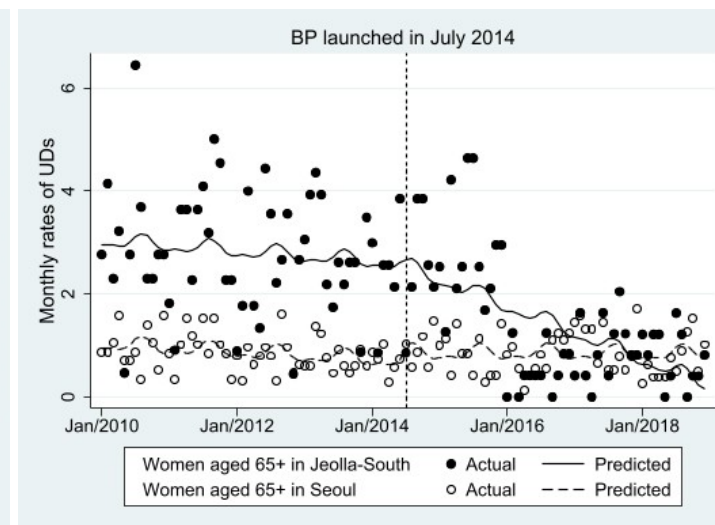
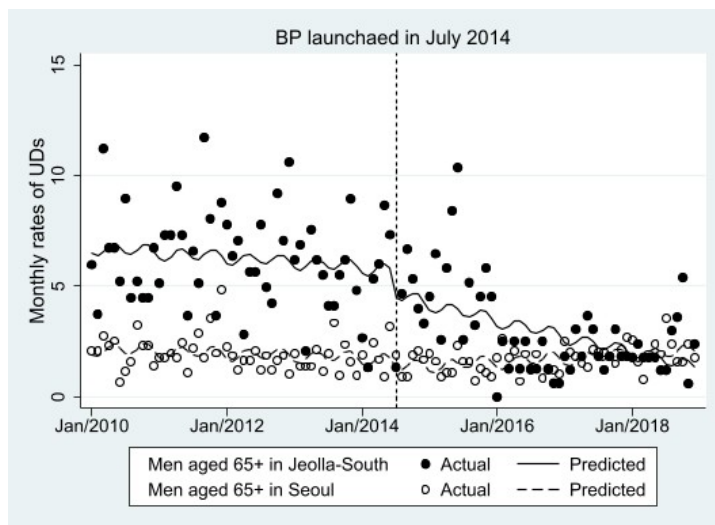


Figure 4.4A-F. CITS using province-based control for the BP: suicide rates and rates of undetermined deaths





APPENDIX

S4.1. Results of Joinpoint Regression of rates of suicides and undetermined deaths in the study period (1997-2018) for older men and women (aged 65+)

(1) Placement of knots: Year 2000 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	22220.64	3	7406.88	F-value (3, 40): 4.47, p=0.0085
Residual	66301.55	40	1657.54	Adjusted R-squared: 0.1948
Total	88522.18	43	2058.66	Root MSE: 40.713
Years	Coefficients	S.E.	P-value	95% C.I.
1997-1999	11.06	9.85	0.268	-8.85 to 30.98
2000-2010	4.67	2.06	0.029	0.51 to 8.82
2011-2018	-9.00	3.57	0.016	-16.21 to -1.79

(2) Placement of knots: Year 2001 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	22737.46	3	7579.15	F-value (3, 40): 4.61, p=0.0073
Residual	65784.73	40	1644.62	Adjusted R-squared: 0.2569
Total	88522.18	43	2058.66	Root MSE: 40.554
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2000	11.02	7.09	0.128	-3.31 to 25.35
2001-2010	4.11	2.26	0.077	-0.46 to 8.69
2011-2018	-8.66	3.60	0.021	-15.94 to -1.39

(3) Placement of knots: Year 2002 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	23504.89	3	7834.96	F-value (3, 40): 4.82, p=0.0059
Residual	65017.29	40	1625.43	Adjusted R-squared: 0.2655
Total	88522.18	43	2058.66	Root MSE: 40.317
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2001	11.03	5.47	0.051	-0.04 to 22.09
2002-2010	3.33	2.51	0.192	-1.74 to 8.41
2011-2018	-8.23	3.63	0.029	-15.56 to -0.90

(4) Placement of knots: Year 2003 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	24380.41	3	8126.80	F-value (3, 40): 5.07, p=0.0045
Residual	64141.78	40	1603.54	Adjusted R-squared: 0.2754
Total	88522.18	43	2058.66	Root MSE: 40.044
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2002	10.84	4.42	0.019	1.90 to 19.79
2003-2010	2.36	2.82	0.408	-3.34 to 8.06
2011-2018	-7.75	3.66	0.040	-15.14 to -0.36

(5) Placement of knots: Year 2004 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	24910.95	3	8303.65	F-value (3, 40): 5.22, p=0.0039
Residual	63611.23	40	1590.28	Adjusted R-squared: 0.2814
Total	88522.18	43	2058.66	Root MSE: 39.878
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2003	10.27	3.71	0.008	2.78 to 17.76
2004-2010	1.38	3.23	0.672	-5.15 to 7.90
2011-2018	-7.35	3.71	0.054	-14.84 to 0.13

(6) Placement of knots: Year 2005 and Year 2011

Males	SS	DF	MS	Number of observations: 44
Model	24969.91	3	8323.30	F-value (3, 40): 5.24, p=0.0038
Residual	63552.27	40	1588.81	Adjusted R-squared: 0.2821
Total	88522.18	43	2058.66	Root MSE: 39.860
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2004	9.49	3.19	0.005	3.04 to 15.93
2005-2010	0.44	3.79	0.908	-7.21 to 8.10
2011-2018	-7.09	3.78	0.068	-14.72 to 0.54

(7) Placement of knots: Year 2005 and Year 2010

Males	SS	DF	MS	Number of observations: 44
Model	25007.11	3	8335.70	F-value (3, 40): 5.25, p=0.0038
Residual	63515.07	40	1587.88	Adjusted R-squared: 0.2825
Total	88522.18	43	2058.66	Root MSE: 39.848
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2004	9.30	3.26	0.007	2.72 to 15.88
2005-2009	1.43	4.57	0.756	-7.80 to 10.66
2010-2018	-6.47	3.26	0.054	-13.05 to 0.11

(8) Placement of knots: Year 2004 and Year 2010

Males	SS	DF	MS	Number of observations: 44
Model	25035.01	3	8345.00	F-value (3, 40): 5.26, p=0.0037
Residual	63487.18	40	1587.18	Adjusted R-squared: 0.2828
Total	88522.18	43	2058.66	Root MSE: 39.839
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2003	9.98	3.77	0.012	2.36 to 17.61
2004-2010	2.35	4.79	0.539	-5.30 to 10.00
2011-2018	-6.63	3.19	0.044	-13.07 to -0.18

(9) Placement of knots: Year 2003 and Year 2010

Males	SS	DF	MS	Number of observations: 44
Model	24674.12	3	8224.71	F-value (3, 40): 5.15, p=0.0042
Residual	63848.06	40	1596.20	Adjusted R-squared: 0.2787

Total	88522.18	43	2058.66	Root MSE: 39.952
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2002	10.41	4.49	0.026	1.33 to 19.49
2003-2009	3.35	3.24	0.307	-3.20 to 9.90
2010-2018	-6.92	3.14	0.033	-13.26 to -0.57

(10) Placement of knots: Year 2002 and Year 2010

Males	SS	DF	MS	Number of observations: 44
Model	24052.56	3	8017.52	F-value (3, 40): 4.97, p=0.0005
Residual	64469.62	40	1611.74	Adjusted R-squared: 0.2717
Total	88522.18	43	2058.66	Root MSE: 40.146
Years	Coefficients	S.E.	P-value	95% C.I.
1997-2001	10.38	5.54	0.068	21.57
2002-2009	4.35	2.84	0.133	10.08
2010-2018	-7.29	3.10	0.024	-1.02

S4.2. Results of Proportions of total older adults who receive basic pension by province and metropolitan cities with administrative status equal to those of provinces.

Year	2016			2017		
	A	B	C (%)	A	B	C (%)
Seoul	1292381	681235	52.7	1355507	725719	53.5
Busan	535628	360176	69.1	564959	395283	70.0
Daegu	328731	222609	67.7	347242	236927	68.2
Incheon	323869	226640	70.0	344530	243877	70.8
Gwangju	172508	113714	65.9	180781	120495	66.7
Daejeon	171445	109586	63.9	180529	116851	64.7
Ulsan	108733	68248	62.8	116587	74115	63.6
Gyeonggi	1372197	718956	59.6	1464958	886410	60.5
Gangwon	265997	184248	69.3	279784	194672	69.6
Chungcheong-North	240606	171027	71.1	252329	180454	71.5
Chungcheong-South	349975	247019	70.6	362771	260907	71.9
Jeolla-North	341112	256186	75.1	351159	266473	75.9
Jeolla-South	398821	323483	81.1	408319	333675	81.7
Gyeongsang-North	492267	372525	75.7	512494	390649	76.2
Gyeongsang-South	480103	346364	72.1	504223	367847	73.0
Jeju	88942	55960	62.9	92824	58272	62.8

A: population; B: number of beneficiaries; C: proportion of beneficiaries

S4.3. Results of sensitivity analyses

(1) Including dummies

BOAP: recession dummy (Year 2008 and 2009)

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Recession	1.211**	1.072	1.367	1.116*	1.005	1.239
t	0.996*	0.994	0.999	0.994***	0.992	0.997
z	3.646***	3.272	4.064	2.138***	1.949	2.345
z t	1.002	0.998	1.006	1.005**	1.001	1.008
x576	0.841	0.685	1.033	0.934	0.783	1.115
x t576	1.017***	1.010	1.025	1.014***	1.008	1.020
z x576	0.936	0.792	1.107	0.936	0.811	1.080
z x t576	0.993	0.986	1.001	0.996	0.990	1.002

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Recession	1.181*	1.019	1.369	1.078	0.961	1.210
t	0.996*	0.992	0.999	0.994***	0.992	0.997
z	3.195***	2.804	3.640	2.029***	1.832	2.246
z t	1.003	0.998	1.007	1.004*	1.000	1.008
x576	0.858	0.670	1.100	0.957	0.789	1.162
x t576	1.019***	1.010	1.028	1.015***	1.008	1.021
z x576	0.891	0.728	1.091	0.867	0.741	1.015
z x t576	0.992	0.984	1.001	0.997	0.990	1.004

UDs	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Recession	1.343*	1.010	1.788	1.261*	1.030	1.545
t	1.001	0.994	1.008	0.994*	0.990	0.999
z	6.373***	4.902	8.285	2.661***	2.226	3.180
z t	1.000	0.990	1.010	1.007	1.000	1.013
x576	0.813	0.497	1.330	0.911	0.645	1.286
x t576	1.007	0.990	1.024	1.009	0.997	1.021
z x576	0.985	0.660	1.472	1.085	0.823	1.430
z x t576	1.004	0.986	1.022	0.998	0.986	1.010

BP (age-based control): pesticide regulation dummy (Year 2012, 2013, and 2014)

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	0.946	0.884	1.013	0.918**	0.872	0.967
_t	0.995***	0.992	0.998	0.999	0.997	1.001
_z	2.905***	2.632	3.206	2.187***	2.027	2.359
_z_t	1.000	0.997	1.003	0.997*	0.995	1.000
_x654	0.937	0.833	1.053	0.841***	0.769	0.920
_x_t654	1.002	0.998	1.006	0.998	0.995	1.001
_z_x654	0.967	0.840	1.112	1.023	0.918	1.139
_z_x_t654	0.995*	0.991	1.000	1.002	0.998	1.005

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	0.932	0.865	1.005	0.899***	0.847	0.954
_t	0.996*	0.993	0.999	1.000	0.997	1.002
_z	2.424***	2.173	2.704	1.960***	1.798	2.137
_z_t	0.998	0.994	1.002	0.996**	0.993	0.999
_x654	0.937	0.822	1.067	0.855**	0.772	0.947
_x_t654	1.001	0.996	1.005	0.997	0.994	1.001
_z_x654	0.985	0.843	1.152	1.044	0.924	1.181
_z_x_t654	0.997	0.992	1.002	1.003	0.999	1.007

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	1.047	0.864	1.269	0.997	0.896	1.110
_t	0.986**	0.977	0.994	0.994*	0.990	0.999
_z	6.099***	4.656	7.990	3.571	3.058	4.169
_z_t	1.010*	1.001	1.019	1.003***	0.998	1.008
_x654	0.885	0.633	1.236	0.669	0.557	0.805
_x_t654	1.010	0.998	1.022	1.003	0.996	1.009
_z_x654	1.028	0.693	1.525	1.150	0.923	1.433
_z_x_t654	0.988	0.976	1.000	0.997	0.990	1.004

BP (province-based control): pesticide regulation dummy (Year 2012, 2013, and 2014)

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	0.917	0.783	1.074	0.831**	0.740	0.932
_t	0.996	0.989	1.003	1.001	0.996	1.006
_z	1.354*	1.075	1.705	1.509***	1.275	1.786
_z_t	1.003	0.996	1.011	1.002	0.996	1.007
_x654	0.972	0.741	1.274	0.815*	0.669	0.992
_x_t654	0.998	0.989	1.008	0.996	0.989	1.003
_z_x654	1.012	0.728	1.407	0.936	0.737	1.188
_z_x_t654	0.982**	0.971	0.992	0.990*	0.983	0.998

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	0.901	0.745	1.088	0.788***	0.690	0.899
_t	0.997	0.989	1.005	1.002	0.996	1.008
_z	0.883	0.669	1.166	1.073	0.886	1.300
_z_t	1.004	0.995	1.013	1.003	0.996	1.009
_x654	0.900	0.653	1.241	0.815	0.651	1.021
_x_t654	0.996	0.984	1.007	0.991*	0.983	0.999
_z_x654	1.025	0.689	1.525	0.946	0.720	1.243
_z_x_t654	0.991	0.978	1.004	0.997	0.989	1.006

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
Regulation	0.921	0.712	1.191	0.907	0.733	1.123
_t	0.995	0.984	1.006	0.999	0.990	1.008
_z	2.817***	1.942	4.085	3.122***	2.279	4.276
_z_t	1.004	0.992	1.016	1.000	0.990	1.011
_x654	1.158	0.745	1.802	0.721	0.500	1.038
_x_t654	1.004	0.988	1.020	1.008	0.995	1.022
_z_x654	0.898	0.527	1.528	1.050	0.672	1.643
_z_x_t654	0.966***	0.950	0.983	0.972***	0.958	0.986

(2) Prais-Winsten

BOAP using age-based control

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.007	-0.019	0.004	-0.037*	-0.074	-0.001
_z	5.003***	4.134	5.872	8.364***	6.457	10.271
_z_t	-0.002	-0.029	0.026	0.016	-0.051	0.082
_x576	0.196	-0.299	0.690	0.343	-1.193	1.879
_x_t576	0.018	-0.003	0.039	0.072*	0.004	0.139
_z_x576	-0.030	-0.975	0.914	0.351	-2.352	3.053
_z_x_t576	0.004	-0.037	0.046	0.006	-0.126	0.137

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.008	-0.018	0.002	-0.034	-0.068	0.000
_z	3.600***	2.912	4.287	6.336**	4.522	8.151
_z_t	-0.003	-0.025	0.019	0.008	-0.053	0.070
_x576	0.178	-0.278	0.634	0.272	-1.257	1.801
_x_t576	0.018	-0.002	0.038	0.070*	0.005	0.134
_z_x576	-0.286	-1.074	0.501	-0.557	-3.082	1.968
_z_x_t576	0.007	-0.029	0.043	0.012	-0.108	0.132

UDs	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.022	-0.046	0.091	-0.092	-0.196	0.012
_z	19.867***	15.020	24.715	1.829	-2.592	6.249
_z_t	0.139	-0.054	0.332	0.298**	0.131	0.464
_x576	0.441	-3.188	4.071	5.012	-0.842	10.866
_x_t576	-0.001	-0.169	0.166	0.049	-0.200	0.298
_z_x576	5.180	-4.182	14.541	8.120	-1.215	17.454
_z_x_t576	0.012	-0.354	0.378	-0.057	-0.490	0.376

BP using age-based control

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.012***	-0.019	-0.006	-0.025**	-0.042	-0.008
_z	3.879***	3.388	4.371	7.692***	6.166	9.218
_z_t	-0.021**	-0.036	-0.006	-0.047*	-0.091	-0.004
_x654	0.022	-0.261	0.304	-0.306	-1.042	0.430
_x_t654	0.009	0.000	0.018	0.014	-0.010	0.039
_z_x654	-0.199	-0.706	0.308	-0.434	-1.743	0.876
_z_x_t654	-0.001	-0.019	0.017	0.032	-0.020	0.084

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.010*	-0.018	-0.002	-0.021*	-0.040	-0.002
_z	2.529***	2.011	3.047	5.266***	3.747	6.784
_z_t	-0.019*	-0.034	-0.003	-0.040	-0.083	0.003
_x654	0.026	-0.255	0.308	-0.056	-0.843	0.731
_x_t654	0.007	-0.003	0.017	0.012	-0.015	0.039
_z_x654	-0.039	-0.505	0.426	-0.144	-1.431	1.143
_z_x_t654	0.004	-0.014	0.022	0.031	-0.021	0.084

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.003*	-0.005	0.000	-0.005**	-0.008	-0.002
_z	1.346***	1.223	1.469	2.366***	2.117	2.615
_z_t	-0.002	-0.006	0.002	-0.005	-0.012	0.003
_x654	-0.008	-0.075	0.059	-0.213*	-0.331	-0.094
_x_t654	0.002	0.000	0.004	0.003	-0.001	0.007
_z_x654	-0.164	-0.343	0.014	-0.417**	-0.728	-0.107
_z_x_t654	-0.005	-0.011	0.001	-0.001	-0.011	0.009

BP using province-based control

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.026**	-0.043	-0.008	-0.044**	-0.073	-0.015
_z	1.643**	0.629	2.657	5.459***	3.359	7.559
_z_t	0.009	-0.025	0.043	0.003	-0.060	0.065
_x654	0.194	-0.501	0.890	-0.181	-1.500	1.137
_x_t654	0.011	-0.010	0.032	0.030	-0.009	0.068
_z_x654	-0.251	-1.812	1.310	-1.100	-3.827	1.628
_z_x_t654	-0.063**	-0.107	-0.018	-0.089	-0.180	0.002

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.019**	-0.032	-0.006	-0.035**	-0.060	-0.010
_z	-0.378	-0.991	0.234	0.793	-1.062	2.649
_z_t	0.013	-0.009	0.034	0.015	-0.039	0.069
_x654	0.043	-0.469	0.556	0.191	-0.976	1.358
_x_t654	0.004	-0.011	0.020	0.007	-0.029	0.043
_z_x654	-0.159	-1.109	0.791	-0.460	-2.562	1.642
_z_x_t654	-0.021	-0.049	0.007	-0.020	-0.095	0.055

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.006	-0.014	0.001	-0.008	-0.024	0.007
_z	2.003***	1.132	2.873	4.617***	3.186	6.047
_z_t	-0.002	-0.028	0.024	-0.010	-0.055	0.036
_x654	0.166	-0.169	0.501	-0.407	-1.037	0.224
_x_t654	0.006	-0.005	0.018	0.023*	0.003	0.043
_z_x654	-0.212	-1.353	0.929	-0.773	-2.774	1.228
_z_x_t654	-0.041*	-0.076	-0.007	-0.069*	-0.130	-0.008

(3) Age-specific

(4) Non-pesticide

npall	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.996**	0.993	0.998	0.999	0.998	1.001
_z	2.532***	2.276	2.816	1.812***	1.676	1.960
_z_t	1.001	0.998	1.005	0.999	0.997	1.002
_x654	0.994	0.893	1.107	0.899**	0.831	0.973
_x_t654	1.002	0.998	1.005	0.999	0.997	1.002

_z_x654	0.957	0.822	1.114	1.022	0.914	1.143
_z_x_t654	0.994*	0.990	0.999	1.000	0.996	1.003

npsuir	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.996*	0.994	0.999	0.998	1.002	0.998
_z	1.971***	1.752	2.218	1.432***	1.716	1.432
_z_t	0.999	0.996	1.003	0.995	1.001	0.995
_x654	1.020	0.905	1.149	0.855	1.026	0.855
_x_t654	1.001	0.997	1.005	0.996	1.002	0.996
_z_x654	0.988	0.834	1.169	0.929	1.204	0.929
_z_x_t654	0.996	0.991	1.001	0.997	1.005	0.997

nondt	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.990**	0.983	0.997	0.997	0.993	1.000
_z	6.078***	4.525	8.165	3.152***	2.689	3.695
_z_t	1.010	1.000	1.019	1.004	0.999	1.009
_x654	0.775	0.565	1.064	0.653***	0.557	0.766
_x_t654	1.006	0.996	1.016	1.001	0.995	1.006
_z_x654	1.080	0.704	1.658	1.139	0.909	1.425
_z_x_t654	0.988	0.975	1.002	0.996	0.989	1.003

(5) Using yearly data

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.905**	0.855	0.959	0.960*	0.928	0.993
_z	2.753***	2.423	3.128	2.111***	1.877	2.374
_z_t	1.030	0.978	1.086	0.992	0.946	1.041
_x2014	1.088	0.831	1.424	0.942	0.820	1.082
_x_t2014	1.063	0.992	1.138	1.006	0.960	1.055
_z_x2014	0.869	0.701	1.077	0.944	0.775	1.149
_z_x_t2014	0.924*	0.858	0.994	1.003	0.938	1.073
all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-1.967***	-2.235	-1.699	-3.105***	-4.287	-1.924
_z	45.425***	43.849	47.000	89.970***	76.146	103.795
_z_t	-1.639***	-2.297	-0.981	-4.452	-9.136	0.231
_x2014	1.361*	0.074	2.649	-2.920	-9.438	3.597
_x_t2014	1.182***	0.729	1.635	0.857	-1.607	3.322

_z_x2014	-7.093**	-10.781	-3.404	-10.846	-27.778	6.086
_z_x_t2014	-1.217	-2.442	0.007	2.171	-3.589	7.931

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.917**	0.862	0.976	0.970	0.934	1.008
_z	2.399***	2.090	2.754	1.893***	1.658	2.161
_z_t	0.992	0.938	1.050	0.980	0.929	1.035
_x2014	1.106	0.828	1.478	0.956	0.817	1.118
_x_t2014	1.053	0.978	1.134	1.001	0.949	1.056
_z_x2014	0.920	0.730	1.160	0.955	0.765	1.194
_z_x_t2014	0.954	0.881	1.033	1.017	0.942	1.098
suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-1.386***	-1.741	-1.031	-2.049**	-3.415	-0.683
_z	30.512***	28.217	32.807	61.054***	44.728	77.379
_z_t	-2.046***	-2.961	-1.130	-3.935	-9.403	1.534
_x2014	0.872	-0.448	2.192	-2.006	-7.585	3.572
_x_t2014	0.738*	0.212	1.263	0.334	-1.780	2.449
_z_x2014	-3.022	-6.812	0.767	-5.627	-24.053	12.799
_z_x_t2014	0.171	-1.012	1.354	2.757	-3.625	9.139

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.828	0.744	0.922	0.905**	0.839	0.975
_z	4.756**	3.751	6.030	3.296***	2.535	4.285
_z_t	1.218***	1.106	1.341	1.060	0.952	1.179
_x2014	0.906***	0.546	1.503	0.811	0.596	1.104
_x_t2014	1.108	0.975	1.259	1.021	0.920	1.133
_z_x2014	0.799	0.535	1.192	1.006	0.649	1.558
_z_x_t2014	0.822**	0.717	0.943	0.960	0.827	1.114
UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	-0.564***	-0.740	-0.388	-1.013***	-1.384	-0.641
_z	14.894***	14.167	15.620	28.635***	25.878	31.392
_z_t	0.408*	0.116	0.701	-0.394	-1.358	0.570
_x2014	0.420	-0.324	1.163	-1.052	-2.901	0.797
_x_t2014	0.444**	0.225	0.663	0.489	-0.273	1.250
_z_x2014	-4.021***	-5.421	-2.620	-5.638**	-9.308	-1.969
_z_x_t2014	-1.411***	-1.857	-0.966	-0.701	-2.504	1.102

(6) Other provinces

Jeolla-North vs. Seoul

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.993*	0.988	0.999	0.995*	0.991	1.000
_z	1.202	0.939	1.540	1.633***	1.361	1.958
_z_t	1.004	0.996	1.012	0.997	0.991	1.003
_x654	1.059	0.830	1.351	0.967	0.807	1.157
_x_t654	1.001	0.994	1.009	1.003	0.997	1.009
_z_x654	0.763	0.534	1.089	1.125	0.868	1.460
_z_x_t654	0.995	0.983	1.006	0.997	0.989	1.006

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.994	0.987	1.000	0.995*	0.991	1.000
_z	1.145	0.850	1.543	1.612***	1.315	1.976
_z_t	0.996	0.987	1.006	0.992*	0.985	0.999
_x654	0.984	0.734	1.318	1.022	0.836	1.251
_x_t654	0.999	0.990	1.009	1.000	0.994	1.007
_z_x654	0.824	0.533	1.274	1.288	0.961	1.727
_z_x_t654	1.007	0.993	1.021	1.006	0.997	1.016

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.992	0.983	1.001	0.996	0.989	1.004
_z	1.386	0.925	2.077	1.805**	1.282	2.542
_z_t	1.017*	1.004	1.031	1.007	0.996	1.018
_x654	1.255	0.851	1.851	0.774	0.555	1.079
_x_t654	1.007	0.995	1.020	1.012*	1.002	1.023
_z_x654	0.575	0.325	1.017	0.957	0.590	1.553
_z_x_t654	0.974**	0.956	0.992	0.975**	0.960	0.990

Gyeongsang-North vs. Seoul

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.994*	0.989	0.999	0.995**	0.992	0.999
_z	1.213	0.972	1.514	1.439***	1.241	1.670
_z_t	0.998	0.991	1.005	0.998	0.993	1.003
_x654	1.051	0.842	1.310	0.966	0.833	1.122
_x_t654	1.001	0.994	1.008	1.003	0.998	1.008

_z_x654	1.032	0.751	1.417	0.963	0.779	1.191
_z_x_t654	1.001	0.991	1.011	1.001	0.995	1.008

suicide	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.994*	0.988	0.999	0.995*	0.991	0.999
_z	1.146	0.894	1.471	1.432***	1.198	1.711
_z_t	0.992	0.984	1.000	0.995	0.989	1.001
_x654	0.979	0.763	1.257	1.023	0.856	1.223
_x_t654	0.999	0.991	1.007	1.000	0.994	1.006
_z_x654	1.364	0.949	1.959	0.960	0.744	1.240
_z_x_t654	1.007	0.995	1.018	1.010*	1.002	1.018

UD	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.992	0.984	1.001	0.996	0.989	1.003
_z	1.350	0.904	2.016	1.489*	1.092	2.031
_z_t	1.010	0.997	1.023	1.005	0.995	1.016
_x654	1.243	0.841	1.836	0.769	0.566	1.043
_x_t654	1.007	0.994	1.020	1.013*	1.003	1.022
_z_x654	0.617	0.351	1.083	1.095	0.706	1.699
_z_x_t654	0.987	0.970	1.005	0.977**	0.964	0.991

(7) Changing pre-intervention periods

2003-2010

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.999	0.996	1.001	0.997**	0.995	0.999
_z	3.546***	3.186	3.947	2.042***	1.859	2.244
_z_t	1.002	0.999	1.006	1.004**	1.002	1.007
_x576	1.049	0.925	1.190	1.038	0.929	1.158
_x_t576	1.007**	1.002	1.013	1.007**	1.002	1.012
_z_x576	0.937	0.786	1.117	0.939	0.805	1.095
_z_x_t576	0.993	0.986	1.001	0.996	0.990	1.003

2002-2010

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	

_t	1.002	1.000	1.004	1.001	0.999	1.002
_z	3.658***	3.296	4.059	2.016***	1.826	2.226
_z_t	1.001	0.999	1.004	1.004**	1.001	1.006
_x576	0.978	0.860	1.112	0.948	0.840	1.069
_x_t576	1.004	0.999	1.010	1.003	0.998	1.009
_z_x576	0.961	0.803	1.149	0.958	0.809	1.135
_z_x_t576	0.995	0.987	1.002	0.997	0.990	1.004

2001-2010

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	1.004***	1.002	1.005	1.003***	1.002	1.005
_z	3.306***	2.960	3.692	1.887***	1.703	2.091
_z_t	1.003*	1.000	1.005	1.004***	1.002	1.006
_x576	0.923	0.801	1.063	0.885	0.777	1.009
_x_t576	1.002	0.996	1.008	1.001	0.996	1.007
_z_x576	0.920	0.755	1.121	0.947	0.788	1.137
_z_x_t576	0.993	0.985	1.001	0.997	0.989	1.004

2000-2010

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	1.005***	1.003	1.006	1.004***	1.003	1.006
_z	2.613***	2.305	2.963	1.488***	1.315	1.685
_z_t	1.006***	1.004	1.008	1.007***	1.005	1.009
_x576	0.903	0.765	1.065	0.857	0.729	1.007
_x_t576	1.002	0.994	1.009	1.000	0.993	1.007
_z_x576	0.826	0.655	1.043	0.855	0.681	1.074
_z_x_t576	0.990	0.980	1.000	0.994	0.984	1.003

BP: using age-based controls: 2011-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.993***	0.989	0.996	0.996**	0.994	0.999
_z	2.994***	2.672	3.354	2.199***	2.021	2.393
_z_t	0.999	0.994	1.004	0.996*	0.992	1.000
_x654	0.993	0.891	1.108	0.917*	0.846	0.995

_x_t654	1.005*	1.000	1.009	1.002	0.999	1.005
_z_x654	0.987	0.846	1.152	1.048	0.935	1.176
_z_x_t654	0.996	0.991	1.002	1.003	0.999	1.007

BP: using age-based controls: 2009-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.993***	0.992	0.995	0.997***	0.996	0.998
_z	2.802***	2.563	3.064	2.126***	1.979	2.284
_z_t	1.001	0.999	1.003	0.999	0.997	1.001
_x654	0.980	0.891	1.077	0.903**	0.838	0.974
_x_t654	1.004**	1.001	1.007	1.001	0.999	1.003
_z_x654	0.955	0.836	1.092	0.994	0.893	1.106
_z_x_t654	0.994**	0.991	0.998	1.000	0.997	1.003

BP: using age-based controls: 2008-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.996***	0.995	0.998	0.999*	0.997	1.000
_z	2.890***	2.638	3.166	2.163***	2.011	2.326
_z_t	1.000	0.998	1.002	0.999	0.997	1.000
_x654	0.909	0.823	1.005	0.865***	0.799	0.937
_x_t654	1.001	0.998	1.004	0.999	0.997	1.002
_z_x654	0.974	0.845	1.122	0.995	0.889	1.114
_z_x_t654	0.995*	0.991	0.999	1.000	0.997	1.004

BP: using age-based controls: 2007-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.998**	0.997	0.999	1.000	0.999	1.001
_z	2.967***	2.716	3.242	2.189***	2.041	2.347
_z_t	1.000	0.998	1.001	0.999	0.997	1.000
_x654	0.868**	0.785	0.960	0.839***	0.775	0.908
_x_t654	0.999	0.996	1.002	0.998	0.996	1.001
_z_x654	0.985	0.855	1.136	0.993	0.888	1.112
_z_x_t654	0.996*	0.992	1.000	1.000	0.997	1.003

BP: using age-based controls: 2006-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.999	0.998	1.000	1.000	0.999	1.001
_z	3.059***	2.809	3.332	2.108***	1.972	2.253
_z_t	0.999	0.998	1.001	1.000	0.998	1.001
_x654	0.838**	0.758	0.927	0.835***	0.772	0.903
_x_t654	0.998	0.995	1.001	0.998	0.996	1.000
_z_x654	0.997	0.864	1.149	0.968	0.866	1.082
_z_x_t654	0.996*	0.992	1.000	1.000	0.996	1.003

BP: using age-based controls: 2005-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.999*	0.998	1.000	1.000	0.999	1.000
_z	3.041***	2.806	3.295	2.083***	1.954	2.220
_z_t	0.999	0.998	1.001	1.000	0.999	1.001
_x654	0.838***	0.759	0.925	0.845***	0.781	0.913
_x_t654	0.998	0.995	1.001	0.999	0.996	1.001
_z_x654	0.989	0.860	1.136	0.960	0.859	1.073
_z_x_t654	0.996*	0.992	1.000	0.999	0.996	1.002

BP: using province-based controls: 2011-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.994	0.986	1.002	0.994*	0.988	0.999
_z	1.581**	1.210	2.065	1.559***	1.284	1.894
_z_t	0.999	0.988	1.010	1.001	0.993	1.010
_x654	1.050	0.813	1.355	0.996	0.827	1.200
_x_t654	1.001	0.992	1.011	1.005	0.998	1.012
_z_x654	1.090	0.757	1.570	0.952	0.730	1.242
_z_x_t654	0.986*	0.973	1.000	0.990	0.981	1.000

BP: using province-based controls: 2009-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.994**	0.990	0.998	0.997	0.994	1.000

_z	1.257*	1.022	1.547	1.412***	1.204	1.656
_z_t	1.004	0.999	1.010	1.003	0.999	1.007
_x654	1.048	0.844	1.301	0.931	0.788	1.099
_x_t654	1.001	0.995	1.008	1.001	0.996	1.006
_z_x654	0.999	0.732	1.363	0.929	0.733	1.177
_z_x_t654	0.981***	0.972	0.990	0.989**	0.982	0.996

BP: using province-based controls: 2008-2018

all	Women			Men		
	coefficient	95% CI		coefficient	95% CI	
_t	0.995**	0.992	0.998	0.999	0.997	1.001
_z	1.189	0.981	1.442	1.485***	1.283	1.719
_z_t	1.004	1.000	1.009	1.001	0.998	1.005
_x654	1.016	0.824	1.252	0.893	0.762	1.048
_x_t654	1.000	0.994	1.006	0.999	0.995	1.004
_z_x654	1.002	0.743	1.353	0.968	0.771	1.214
_z_x_t654	0.981***	0.973	0.989	0.991**	0.984	0.997

CHAPTER 5

CONCLUSION

Principal findings

The overarching purpose of this dissertation is to advance our understandings of socioeconomic inequality in suicide and suicidal behaviour by providing a systematic analysis of socioeconomic inequality in suicide and suicidal behaviour and roles of social policy and welfare generosity on suicide and suicide inequality. Using a scoping review approach in Chapter 2 (Study 1) allows for an in-depth exploration of the knowledge base on the socioeconomic inequalities in suicidal behaviour, and thus identify the gaps and research agenda that should be addressed. Chapter 3 and Chapter 4 (Study 2 and Study 3) contribute by generating empirical evidence about how relative welfare generosity can be associated with lower employment-based inequalities in Canadian provinces and whether a single policy designed to significantly decrease the level of poverty for the senior citizens resulted in the reduction of suicide mortality at the population-level. I summarize the key findings from the three independent studies in the following paragraphs.

Study 1: Socioeconomic Inequalities in Suicide and Suicidal Behaviour: a Scoping Review

In Chapter 2, the comprehensive review of 96 studies has yielded a series of important findings: 1) SEI in suicidal behaviour measured by adulthood SEP exists in almost all included countries, although childhood SEP did not have independent associations with suicidal behaviour after adjusting for adulthood SEP and even had reverse associations among women; 2) education is the most commonly used indicator for measuring SEI in suicidal behaviour, but education was less consistent than other SEP measures, especially

for women and in suicide mortality; 3) employment status was the most robust indicator of SEI in suicide mortality out of all SEP measures, while little difference is shown among income, occupation and employment status in suicide ideation and attempts; 4) stratified analyses found that, overall, less pronounced SEI in suicidal behaviour was observed within women, African Americans, and first-generation immigrants; 5) although many studies controlled familial status as a critical confounder of SEI in suicidal behaviour, few addressed the complex relationship between the two. There was only weak evidence that unemployed status had synergistic effects with single/divorced status on suicide mortality; 6) mental health status was assumed to be a confounder in almost all studies and no empirical study was found that conceptualized it as a mediator, although one study found that mental health status may play a role as an effect modifier; 7) the relationship between macro-economic circumstances and SEI in suicidal behaviour is contingent upon the context of each case, but all included studies reported that there was a widening of SEI in suicide mortality in the 1990s; 8) studies examining whether area-level SEP had contextual effects on suicidal behaviour showed inconclusive findings. Based on the findings, we identified the knowledge gap surrounding understanding the socioeconomic inequalities in suicidal behaviour and the related factors.

Study 2: Employment-based Inequalities in Suicide Mortality and the Role of Welfare State in Canadian Provinces

In turn, Chapter 3 aimed to investigate whether the generosity of social policy measured via provincial social expenditure has protective impacts on overall suicide mortality and/or moderation impacts on the association between individuals' employment

status and suicide risk in Canada. The findings showed that the main effects of all the expenditure variables are not associated with decreased risks of suicide for Canadians, but that more expenditures in social assistance and total government spending is associated with decreased lower employment-related inequalities in suicide mortality. Lastly, the effects of welfare generosity turned out to be greater among women, but no gender interaction was detected in our analyses. While previous micro-macro analyses have investigated the effects of welfare generosity on health in relation to individual-level socioeconomic positions, few studies have tested the effects on so-called “hard outcomes”, which is considered more objective and valid than subjective outcomes, such as suicidal ideation or self-reported mental health status¹.

Study 3: Impacts of Old-Age Income Security Programs on Suicide Mortality in South Korea: Controlled Interrupted Time-series (CITS) Analyses

Finally, Chapter 4 purposed to evaluate the policy effects of two social pension reforms—one to extend the population coverage of existing social pensions and the other to double the amount of the benefits—on suicide and undetermined intent mortality of older adults in South Korea. We found that the BOAP, which expanded beneficiaries while keeping the benefit level low, did not lead to significant reductions in suicide and UDs for older populations, immediately after the implementation and in the post-intervention period. However, although it did not reach the statistical significance, the pre-post difference was consistently smaller than controls and some sensitivity analyses reached significance among women. Meanwhile, the BP, which increased benefits while maintaining the population coverage, significantly reduced deaths from suicides and undetermined deaths. In the CITS analysis using age-based controls, the BP brought

about 0.5% of additional reductions in suicides plus UDs among women aged 65+ per month on average in the post-intervention periods, which indicates that such a decrease during the post-intervention period would have resulted in approximately 2,150 fewer deaths by suicides and UDS in women. In the CITS analyses using province-based controls, older men and women in Jeolla-South experienced annual reductions in the pre-post trends compared with those of older men and women in Seoul of 1% and 1.8%, respectively, per capita, per month, on average. This corresponds to a reduction in rates of suicides and UDs by 38.3% and 58.2% in total for four years among older men and women, respectively, in Jeolla-South province, compared to older populations in Seoul.

Contributions

Overall, my dissertation contributes to a broad body of research on social determinants of suicide by presenting that inequalities in suicide and suicidal behaviour are universal and unjust public health issues. Even though social and welfare policies were not designed to improve health, they may be an effective means to ameliorate inequalities in suicide and suicidal behaviour. On one hand, despite the abundance of studies examining the roles of social and welfare policies on health outcomes, literature examining its impacts on the outcome of suicide mortality was very limited. On the other hand, due to the apathy in socioeconomic inequality in suicide research, efforts to explore the relationship between social policy and suicide were quite rare. In the section that follows, I present the contribution of each Chapter of the dissertation.

Providing a comprehensive knowledge base on socioeconomic inequalities in suicide and suicidal behaviour

Most previous studies summarizing the relationship between SEP and suicide/suicidal behaviour addressed SEP only as a part of a broader range of social determinants, but rarely focused on the inequity issue as an independent element of research. Moreover, of the few reviews that did focus on the issue of inequity, many had limitations, including focusing only the effects of aggregate-level indicators, restricting the research question to only summarizing the extent of the inequity, and limiting the geographical scope of research to only low- and middle-income countries. Virtually no research has comprehensively summarized studies that examined the relationship between SEP and suicide and suicidal behaviour with heterogeneous research designs and relevant factors affecting the relationship, with a special focus on the inequity. The first contribution of my dissertation is to provide a comprehensive knowledge base on socioeconomic inequalities in suicide and suicidal behaviour. The scoping review in the dissertation examines the extent of SEI in suicidal behaviour, ranging from suicidal ideation to suicide attempts and deaths following the definition of the concepts of suicidal behaviour outlined in the relevant literature, map published research and synthesize their findings about SEI in suicidal behaviour as it relates to factors that moderate the inequities, and identify the gaps in our knowledge and outline a research agenda which will fill them. The research agenda found through the review is valuable for future research exploring the socioeconomic inequality in suicide.

Conceptualizing welfare generosity as a contextual factor influencing suicide and employment-based inequalities in suicide

A growing body of time-series studies have been done on the association between individual social policies and suicide outcomes or its inequality². However, no study to

date has conceptualized welfare generosity as a possible moderator of employment-based inequality in suicide mortality in the multilevel framework. Most multilevel studies examining the contextual factors of health outcomes have been done on a limited set of outcomes, such as self-rated health and other subjective indicators. Using provincial variations in relative welfare generosity over Canadian provinces, Chapter 3 performed a novel micro-macro study of the relationship between relative welfare generosity and suicide mortality and inequalities in suicide mortality. In particular, the Chapter highlights that an individual policy, as well as overall relative generosity given the economic scale may also have an impact in reducing the employment-based inequality in suicide mortality.

Supplementing the limited empirical evidence on social policies targeting older adults in immature welfare states

An emerging body of literature has shown that social policies targeted at the working-age population, such as increasing minimum wage, earned income tax credits, and unemployment insurance, has significant associations with subsequent reductions in suicide mortality³⁻⁵. However, to the best of our knowledge, no published studies to date has ever focused on older populations and policies aimed at helping them. Chapter 2 fills this gap by evaluating old age income security program reforms on elderly suicide mortality, using rigorous quasi-experimental research designs with a variety of robustness checks. Moreover, the study also contributes to the research on the impacts of income security programs in the geographical settings where welfare states are underdeveloped.

Limitations

Although Chapter 2 aims to summarize a broader body of knowledge on socioeconomic inequalities in suicide and suicidal behaviour, the study has inherent limitations due to the nature of the scoping review. First, the study cannot apply strict criteria for filtering studies and conducting the quality assessment tests, because of relatively broader criteria. Second, since it is not a meta-review, the summary of existing studies is narrative, and we cannot generalize the findings. Nevertheless, a scoping review has its own inherent advantages, compared to the systematic review, being well suited to accommodate greater bodies research to map and classify research domains and relevant topics.

Chapter 3 has a number of caveats needed to be noted in terms of data. It makes use of data from two different sources: the Canadian Census and Health and Environment Cohort (CanCHEC) and the Canadian Socio-Economic Information Management System (CANSIM). While CANSIM is an annual time-series dataset, individual-level variables available from CanCHEC were measured only at the baseline. This prevents us from exploring the possibility that employment status and other individual-level factors (such as residence in the province) changed during the follow-up period. Likewise, even though we have information about temporal variations in the welfare generosity, it is impossible to exploit it in the model.

Chapter 4 uses vital statistics for calculating suicide and undetermined mortality. The data contains a lot of information including educational attainment and occupations, but due to the absence of the parallel population data for the sub-groups, we could not use it for the interrupted time-series analyses. It would be possible to include better controls

using such information if we could calculate age-sex-education specific rates of suicide and undetermined deaths.

Implications for social and health policy

As mentioned in the introduction, SEI in suicide and suicidal behaviour has been neglected by most governments in HICs. This is the case in Canada and Korea as addressed in this dissertation. This study has shown that in addition to social policies addressing the adverse effects of socioeconomic deprivation could impact suicide prevention and reduce inequality, there can be a wide array of public health policy measures taken to reduce suicide inequalities. The following is the public health and social policy suggestions derived from the findings in this dissertation.

First, health policy makers should recognize that for the general population without any history of psychiatric illness, employment status is the most consistent predictor of suicidal behaviour among the working-age population. Thus, suicide prevention programs for the general population need to target the unemployed and those involuntarily economically inactive to reduce the inequities in suicidal behaviour. Active labour market programs, more generous unemployment benefits in terms of higher income replacement, longer duration, less stringent eligibility, and the provision of social and mental health services for those marginalized in the labour market and especially individuals who experience additional deprivation (e.g., family dissolution, lack of social supports) can be potentially effective interventions that reduce the overall suicide and simultaneously narrow the gaps between the fully employed and those who are not. In addition to findings from my empirical studies, a growing number of quasi-experimental

studies have found that more generous social and welfare policy targeted at either the working-age or overall population with low SEP is associated with lower suicide mortality and its inequality. For example, recently published articles examining the impacts of minimum wage in the US led to reductions in overall suicide rates and decreasing gaps in suicide mortality among those with a high school education or less and those with bachelor's degree^{3,4}. Cash-transfer programs targeting vulnerable farmers were followed by considerable reductions in suicide mortality in the population in Indonesia⁶. The impact of unemployment rates on suicide mortality was offset by the presence of more investments in active labour market programs and more generous unemployment benefit programs and more expenditure in European countries and the US^{7,8}.

Second, income security programs which guarantee a normal and socially acceptable standard of living may be a strong and effective measure of preventing suicide among older adults. As shown in Chapter 4, basic income security programs for older adults who suffer from widespread poverty, led to significant reductions in overall suicide mortality. Securing an adequate standard of living through conditional/unconditional cash transfer programs for those vulnerable to both socioeconomic deprivation and suicide risks is not only a human rights matter, but is a simple and straightforward way to reduce both suicide mortality, income inequity and inequities in a variety of potential health outcomes, including suicide. In addition, findings in Chapter 4 also show a possible threshold effect – in other words, an income supplement that is too low to reach a sufficient standard of living may not have impacts. This implies that threshold effects may be a plausible explanation for higher risks among social welfare recipients than the

unemployed, despite the existence of benefits for the disabled, those marginalised in the labour market, and the elderly.

Third, health policy researchers need to implement suicide equity impact assessments for suicide prevention programs and policies that have already been implemented to develop and implement evidence-based intervention on the inequity. This is necessary since many of the public health interventions neglecting equity may unintentionally exacerbate health inequalities. From the scoping review, we confirm that there can be myriad factors that modify the relationship between socioeconomic positions and suicidal behaviour. For example, given that socioeconomic inequalities in alcohol-related suicide mortality are significantly higher than non-alcohol-related suicide mortality, it is assumed that policies to restrict alcohol consumption might have additional protective impacts on those with lower SEP. Likewise, no study to date has been done to examine the roles of means restriction on the social class based-inequalities in suicide mortality, despite mounting evidence showing that means restriction has causal effects to reduce suicide deaths.

Last but not least, in order to reflect and implement the previous three suggestions, Health in All Policies (HiAP), as a priority in suicide prevention program, should be the norm. The World Health Organization's Commission on the Social Determinants of Health 2008 report suggested that HiAP must be adopted as a governmental strategy to improve population health and narrow health inequalities. HiAP refers to "a strategy that seeks to integrate health considerations into the development, implementation and evaluation of policies across various non-health sectors of the government."⁹ HiAP is being adopted more readily as a governmental strategy to assess the potential health

impacts of public policies, thereby improving health outcomes and narrow health inequalities¹⁰. An important finding in Chapter 3 is that while there are considerable interprovincial variations in suicide mortality and the inequalities, relative welfare generosity explained some of these variations. Since suicide is a multifaceted phenomenon and given that both social expenditures and total government spending are associated with lower suicide mortality, the HiAP approach may be particularly effective in suicide prevention. An intersectoral approach to suicide prevention could leverage the policy process, from agenda-setting through to implementation and evaluation, to work towards the common goal of decreasing suicide rates and reducing the inequalities in suicide rates by targeting those with lower SEP. This could maximize the efficacy of policies in each sector.

Conclusion

The field of suicidology has identified a number of social determinants of suicide and suicidal behaviour. Despite this, socioeconomic inequalities in suicide have been under-examined for a long time. The surprising apathy has neglected the possibility of reducing the inequity in suicide and its overall risks by tackling the adverse effects of socioeconomic deprivation. This dissertation provides a comprehensive summary of what we know and what we do not know about current status of socioeconomic inequalities in suicide. Also, it explores the roles of welfare generosity and an income security program on suicide and its inequalities. The dissertation's findings point to the severity of inequalities in suicide and suicidal behaviour and the importance of social and economic policies as a viable intervention option to tackle this unjust tragedy.

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