

From THE INSTITUTE OF ENVIRONMENTAL MEDICINE
Karolinska Institutet, Stockholm, Sweden

PRECARIOUS EMPLOYMENT AND OCCUPATIONAL INJURIES IN SWEDEN

Bertina Kreshpaj



**Karolinska
Institutet**

Stockholm 2022

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Published by Karolinska Institutet.

Printed by Universitetservice US-AB, 2021

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ISBN 978-91-8016-539-6

PRECARIOUS EMPLOYMENT AND OCCUPATIONAL INJURIES IN SWEDEN

THESIS FOR DOCTORAL DEGREE (Ph.D.)

By

Bertina Kreshpaj

The thesis will be defended in public on the 18th of March 2022
Venue: Tor, Solnavägen 4, 113 65, Stockholm

Principal Supervisor:

Associate Professor Theo Bodin
Karolinska Institutet
Institute of Environmental Medicine
Unit of Occupational Medicine

Opponent:

Ph.D. Mari Holm Ingelsrud
Oslo Metropolitan University
Work Research Institute

Co-Supervisors:

Professor Tomas Hemmingsson
Karolinska Institutet
Institute of Environmental Medicine
Unit of Occupational Medicine

Examination Board:

Professor Kristina Håkansson
Gothenburg University
Department of Sociology and Work Science

Ph.D. Carin Håkansta
Karolinska Institutet
Institute of Environmental Medicine
Unit of Occupational Medicine

Professor Bengt Järholm
Umeå University
Department of Occupational and
Environmental Medicine

Assistant Professor Cecilia Orellana
Karolinska Institutet
Institute of Environmental Medicine
Unit of Occupational Medicine

Senior Researcher Anne Richter
Karolinska Institutet
Department of Learning, Informatics,
Management, and Ethics

To all those who feel on the edge and who never surrender.

“One never notices what has been done;
One can only see what remains to be done.”

Marie Salomea Sklodowska Curie

ABSTRACT

Nowadays, employment arrangements come under many different forms, often difficult to trace in the statistics due to a lack of standard definitions and measurements. Precarious Employment (PE) is a multidimensional construct constituted by several elements of low-quality employment conditions, and increasing evidence has associated this construct with an array of unfavorable mental and physical health outcomes. However, there is still a lack of a commonly recognized definition of PE, which results in methodological challenges when measuring this multifaceted concept. Furthermore, while PE has been associated with a range of health outcomes, little is known in Sweden regarding under-reporting levels of Occupational Injuries (OIs) among precarious workers and, ultimately, how PE is associated with OIs. Therefore, the overarching aim of this thesis was to advance the development of PE as an occupational exposure and investigate its relation to under-reporting levels of OIs and risks of OIs among the precarious and non-precarious working population in Sweden.

In **Study I**, a systematic review of definitions and operationalizations was carried out in the literature. A total of 63 full-text articles were included in the study, and thematic analysis was performed to identify the core characteristics of PE. Three dimensions were identified: employment insecurity, income inadequacy, and lack of rights and protection. The dimensions were further represented by a total of nine items. Dimensions and items identified in the review facilitated guidance and the operationalization of the Swedish Register-based Operationalization of Precarious Employment (SWE-ROPE) in **Study II**. SWE-ROPE was operationalized in 2014 in the Swedish working population (n. 4,349,322) following a typological and summative scale approach. As a result of latent class analysis (LCA), the typological approach identified six employment types in which one PE-type emerged and was associated with female gender, low education, foreign background, and young age. The summative scale resulted in a score ranging between -10 and +2 with approximately 80% of individuals in PER-type having a score of -4. In **Study III**, PE was measured as a summative scale, and OIs were stratified according to injury severity (no health care, outpatient care, in-patient care). Swedish registries were used to perform capture-recapture methods and estimate under-reporting levels of OIs among precarious and non-precarious workers in Sweden in 2013.

Higher levels of under-reporting of OIs were seen among precarious workers (22.6%, 95%CI 21.3% to 23.8%) compared to the other groups. Also, under-reporting of OIs decreased as injury severity increased and was higher among all occupations in the precarious group.

Study IV aimed to investigate PE as a risk factor for OIs in Sweden between 2006-2014, employing multivariate logistic regression models. The study was set as a prospective register-based study that included employed workers aged 18-65. PE was measured as a summative scale and by looking at each specific PE dimension, while OIs were dichotomized as having or not having an OI during the year. Precarious workers were not found at higher risks of OIs compared to non-precarious workers ($OR < 1$). While male workers employed by an agency, workers in multiple jobs/sectors, and women in the low-income groups were at higher risks of OIs.

In conclusion, this thesis contributed to the methodological advancement of PE as an occupational exposure in Sweden through the work performed in Study I-II. It further shed light on its relationship with under-reporting levels and risks of OIs in the Swedish labor market. In Study III highest under-reporting levels were found among precarious workers compared to non-precarious workers, and in Study IV, increased risks of OIs were found among multiple-job holders, workers employed by an agency, and individuals with poor income.

To date, research practice and policy have based the quantification of workplace hazards on the standard employment relationship (SER). However, today's segmented labor market structure could intensify existing hazards or create new ones. Thus, conventional approaches to research, interventions, and policies may no longer be adequate. By increasing the understanding between PE and OIs, it may be possible to develop programs and policies to increase workers' protection in the labor market. Organizations may also develop targeted health and safety programs to address root causes of OIs. Quantifying and monitoring the possible impact of a new exposure such as PE to known occupational risk factors becomes fundamental if we want to avoid reinforcing prevailing inequalities in our society.

POPULAR SCIENCE SUMMARY

Whether you sit in an office all day or you deliver pizza with your bike, how would you cope if you would not know if and for how long your contract is going to be renewed? Or when you do not know how much you will earn next month? Or perhaps if you get an injury at work, but you cannot stay home since you are not entitled to sick leave through your employment?

Work has been central in our lives for centuries, from a young age until later stages in our life, where it is supposed to bring independence and certainty. However, for those precariously employed, it is failing to do so. It is challenging to draw conceptually a line between precarious and non-precarious employment since even workers in the same workplace might be affected differently based on their employment relationship. This means, for example, that if you have a short-term contract, you may face more difficulties exercising your rights at work than a colleague who has a permanent contract. Or you might not have much choice in deciding your working hours and pay, or you might not receive proper training in your new working environment since you are not going to remain too long in any case. But how is precarious employment affecting workers' health? Many studies have shown its negative impact on physical and mental health, such as stress, anxiety, or an increase in workplace injuries. But when trying to measure the impact of precarious employment on our lives or our health, each study uses a different definition or assessment, and thus comparability across studies is difficult.

So, what does Precarious Employment mean? Since there is no universally accepted definition of precarious employment, in **Study I**, we revised and analyzed the existing literature. We concluded that three major aspects characterize this concept: employment insecurity, income inadequacy, and lack of rights and protection. Each of these aspects were further characterized in sub-aspects to facilitate the measurement in **Study II**. To measure precarious employment in Sweden, we used register data collected at the individual-level for the Swedish working population in 2014.

To identify precarious workers, two different approaches were adopted. The first was data-driven, and individuals sharing similar characteristics in the labor market were clustered together into employment typologies, of which some were precarious. The second assigned a score from -2 to +2 based on an individual's employment quality, assigning low scores to poor employment relationships.

A fifth of the working population was found precarious, having unstable employment, poor income, and not much access to rights and protection in the workplace. Among these, some individuals were found more often than others to be in precarious employment: women, young adults, foreign-born workers, and individuals with low levels of education. After having defined and measured precarious employment, we asked ourselves whether reporting an injury at work depends on whether you are precariously employed or not. Thus, in **Study III**, we included individuals who had a workplace injury in 2013 and defined workers in Sweden as precarious or not using the scoring method. We further developed a model that helped us estimate how much under-reporting there is across gender, age, educational level, and occupations. We found that not reporting a workplace injury was 50% higher among precarious workers than non-precarious workers. Furthermore, whether the injury led to the hospital or not, under-reporting was still higher among precarious workers, regardless of the individual being hospitalized, or have been only to the out-patient care or none of these. In the last study, **Study IV**, we wanted to check if precarious workers were at higher risk of injury in the workplace than non-precarious workers. To do so, we again used the scoring method to identify precarious workers in the Swedish labor market between 2006 and 2014. Even when considering under-reporting levels of injury at work, we did not find precarious workers at higher risk. Nevertheless, we found individuals employed by an agency, those working in multiple jobs across different economic sectors, and those having low earnings, presenting a higher risk of workplace injuries.

In conclusion, all the studies allowed us to identify those precariously employed in Sweden, understanding whether under-reporting workplace injuries is higher among precarious workers and if these are also at higher risks of occupational injuries. The rise of new forms of employment and the increased segmentation of labor markets could worsen existing workplace hazards or create new ones. Thus, monitoring how precarious employment and injuries in the workplace develop over the life course allows the creation of policy and counter-measures aimed at improving workers' protection in the labor market and developing health and safety programs addressing root causes workplace are injuries.

LIST OF SCIENTIFIC PAPERS

The thesis is based on four scientific papers. The papers will be referred to in the text by their Roman numerals (I-IV).

- I. **Kreshpaj B**, Orellana C, Burström B, Davis L, Hemmingsson T, et al. *What is precarious employment? A systematic review of definitions and operationalizations from quantitative and qualitative studies*. Scandinavian journal of work, environment & health 2020;46(3):235-247.
- II. Jonsson J, Matilla-Santander N, **Kreshpaj B**, Orellana C, Johansson G, et al. *Exploring multidimensional operationalizations of precarious employment in Swedish register data - a typological approach and a summative score approach*. Scandinavian journal of work, environment & health. 2021;47(2):117–26.
- III. **Kreshpaj B**, Bodin T, Wegman DH, Matilla-Santander N, Burstrom B, et al. *Under-reporting of non-fatal occupational injuries among precarious and non-precarious workers in Sweden*. Occupational and Environmental Medicine. 79(1):3-9. doi: 10.1136/oemed-2021-107856. Epub 2021 Sep 20.
- IV. **Kreshpaj B**, Wegman D, Burström B, Davis L, Hemmingsson T, et al. *Precarious Employment as a risk factor for occupational injuries in Sweden: a repeated prospective register-based study* (Manuscript)

ASSOCIATED SCIENTIFIC PAPERS NOT INCLUDED IN THE THESIS

- I. Orellana C, **Kreshpaj B**, Burstrom B, Davis L, Frumento P, Hemmingsson T, et al. *Organisational factors and under-reporting of occupational injuries in Sweden: a population-based study using capture-recapture methodology*. Occupational and environmental medicine. 2021;78(10):745-752
- II. Orellana C, **Kreshpaj B**, Johansson G, Burström B, Kjellberg K, Hemmingsson T, et al. *Precarious employment, business performance and occupational injuries: a study protocol of a register-based Swedish project*. BMJ open 2019;9(2):e026091
- III. Gunn V, **Kreshpaj B**, Matilla-Santander N, Vignola EF, Wegman DH, Hogstedt C, et al. *Initiatives addressing precarious employment and its effects on workers' health and well-being: A systematic review*. International Journal of Environmental Research and Public Health 2022;
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- V. Jonsson J, Matilla-Santander N, **Kreshpaj B**, Johansson G, Kjellberg K, Burström B, et al. *Precarious employment and general, mental and physical health in Stockholm, Sweden: a cross-sectional study*. Scandinavian journal of public health 2021;49(2):228 - 236
- VI. Matilla-Santander N, Jonsson J, **Kreshpaj B**, Orellana B, Benach J, Badarin K, et al. *The relation between precarious employment arrangements and social precarity -findings from the PREMIS study in Stockholm, Sweden*. International Journal of Health Services 2021;():207314211051880

- VII. Kwart S, Jonsson J, Bodin T, Håkansta C, **Kreshpaj B**, Orellana C, et al. *Precarious employment and psychosocial hazards: a cross-sectional study in Stockholm County*. International journal of environmental research and public health 2021; 18(21):11218. doi: 10.3390/ijerph182111218
- VIII. Aktas E, Bergbom B, Godderis L, **Kreshpaj B**, Marinov M, Mates D, Mcelvenny Dm, Mehlum Is, Milenkova V, Nena E, Glass D. *Migrant workers occupational health research: an OMEGA-NET working group position paper*. International archives of occupational and environmental health 2021; 1-13. doi: 10.1007/s00420-021-01803
- IX. Gunn V; Håkansta C; Vignola E; Matilla-Santander N; **Kreshpaj B**; Wegman D.H.; et al. *Initiatives addressing precarious employment and its effects on workers' health and well-being: A protocol for a systematic review*. BMC Systematic Reviews journal. 2021;10(1):195
- X. Jonsson J; Muntaner C; Bodin T; Alderling M; Balogh R; Burström B; et al. *Low-quality employment trajectories and risk of common mental disorders, substance use disorders and suicide attempt in Sweden*. Scandinavian journal of work, environment & health: accepted and under-review 2021
- XI. Matilla-Santander N, Ahonen E, Albin M, Baron S, Bolívar M, Bosmans K, et al. *COVID-19 and Precarious Employment: Consequences of the Evolving Crisis*. International journal of health services : planning, administration, evaluation 2021;():20731420986694-
- XII. Bodin T, Çağlayan Ç, Garde AH, Gnesi M, Jonsson J, Kiran S, et al. *Precarious employment in occupational health - an OMEGA-NET working group position paper*. Scandinavian journal of work, environment & health. 2020;46(3):321-9. doi: 10.5271/sjweh.3860.
- XIII. Rönnblad T, Grönholm E, Jonsson J, Koranyi I, Orellana C, **Kreshpaj B**, et al. *Precarious employment and mental health: a systematic review and meta-analysis of longitudinal studies*. Scandinavian Journal of Work, Environment & Health. 2019;5(45):429-43. doi: 10.5271/sjweh.379

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LIST OF ABBREVIATIONS

AFA	Insurance fund owned and managed by Sweden's labor market parties
AVVEP	Average Posterior Probabilities
BO	Business Owners
CBA	Collective Bargaining Agreement
CI	Confidence Intervals
DAG	Direct Acyclic Graphs
DR	The cause of Death Register
EU	European Union
EPRES	Employment Precariousness Scale
GDP	Gross Domestic Product
ICD	International Classification of Disease
ISA	Swedish information system on occupational accidents and work-related diseases
LCA	Latent Class Analysis
LISA	The longitudinal integration database for health insurance and labor market studies
LO	Swedish Trade Union Confederation
NPR	The National Patient Register
NSWA	Non-Standard Work Arrangements
OECD	Organization for Economic Co-operation and Development
OI	Occupational Injury
OR	Odds Ratios
PE	Precarious Employment
PEPSO	Poverty and Employment Precarity in Southern Ontario
PER	Precarious Employment Relationship
PTK	The Council for Negotiation and Co-operation
SER	Standard Employment Relationship
SDG	Sustainable Development Goals
SEK	Swedish Krona
SWE-ROPE	Swedish Register-based Operationalization of Precarious Employment

1 INTRODUCTION

Little is known about OIs among precariously employed workers in Sweden. PE is an acknowledged social determinant of health, characterized by low-quality employment conditions associated with adverse physical and mental health outcomes [1, 2]. Nevertheless, the lack of an internationally accepted definition and operationalization of PE severely hampers the investigation of OIs among precarious workers and restricts comparisons between existing studies. Currently, there is no precise estimation of how many OIs are not reported in Sweden every year, especially among workers in a vulnerable labor market position, such as precarious workers. Such under-reporting may alter the relationship between PE and OIs and challenge surveillance and preventive measures to reduce OIs in the workplace. Overall, the relationship between PE and OIs is poorly understood and, the majority of the literature investigating associations is cross-sectional.

Because the nature of work is continuously changing, it is cogent to characterize new occupational hazards that could increase OIs. Therefore, this thesis aims at filling some of the above-mentioned knowledge gaps by advancing the development of PE as a multidimensional exposure, thus improving the understanding of potential mechanisms and associations between PE and OIs in Sweden. Four peer-reviewed scientific articles have been performed and found at the end of this thesis.

2 BACKGROUND

2.1 Societal changes and the modern world of work

With an increase in longevity and retirement age, the world of work is for the first time, witnessing four different generations working side by side in the labor market: baby boomers, generation x, millennials, and generation z. Each of these generations has entered the labor market in different historical, economic, political, and technological moments (so-called megatrends), which inevitably shape and create different understanding and expectations of what work and employment mean. On the one hand, the working life of baby boomers who were born in the 1940's and generation x born in the 1969's, is shaped by the SER, universally considered the gold standard of the employment relationship and characterized by full-time, dependent, and indefinite employment that ensures job stability and access to social benefits, healthcare, and workplace rights [3]. On the other hand, the working life of millennials and generation z (born respectively in the 1990's and 2000's) is shaped by the rise of new forms of employment that diverge from SER. These new forms of employment are referred to as non-standard work arrangements (NSWA) and cover a broad spectrum of workers, including part-time workers, temporary workers, agency workers, dependent and independent contractors, gig workers, and platform workers [4].

The increased demand for a flexible workforce to survive megatrends has resulted in a deterioration of labor relations where vulnerable groups on the labor market are at risk of being locked in a permanent state of precarity [5, 6]. The increase of NSWA facilitates low-quality employment conditions that do not ensure decent working and living standards for workers and their families, as PE [7, 8]. PE is a much-debated term constituted by poor employment conditions, such as insecure employment, low salary, bad working conditions, limited access to workplace rights [6, 9, 10]. These phenomena have become a feature of the labor market worldwide and across Europe [8, 11]. Labour market fragmentation was intensified by the global financial and social crisis in 2008 and the current COVID-19, which underlined the vulnerability of certain categories of workers in the labor market [12].

2.2 The Nordic model, Sweden and the new world of work

The combination of social welfare and economic systems adopted by the Nordic countries - Denmark, Sweden, Norway, Finland, and Iceland- are referred to as the “Nordic Model”.

Such a model is considered a benchmark, where the Nordics are considered to succeed more than other countries in combining economic efficiency, growth of the labor market, a fair distribution of income, and a sound social security system [13]. While there are substantial economic and political differences among them, Nordic countries share some major similarities, such as a comprehensive welfare state, high public and private expenditures on human capital (including childcare, education, health care, etc.), strong labor unions, and employer associations which play an active role as to labor market policies [13].

Nevertheless, they are not exempt from the pressure of past and present megatrends that consequently affect and change the labor market. Nowadays, a third of all employment relationships in the Nordics can be considered NSWA [14, 15]. Along with labor market changes, the regulatory context of these new forms of employment is changing, which means that risks and insecurities around employment relationships are also changing [14-16].

The debate on the deterioration of labor relations has reemerged across the Nordic countries. Sweden’s gradual liberalization of temporary employment contracts and reformation of the regulation of staffing agency companies has led to an increase in fixed-term employment [16, 17]. In 2013, Sweden was ranked by the OECD as one of the countries with the largest gap in employment regulations between permanent and fixed-term employment [18]. This change in employment regulations allowed employers to prolong the use and length of temporary employment contracts. Consequently, in 2015 14% of workers in Sweden were engaged in fixed-term employment [14] and in 2018, it was described as having the highest level of job insecurity in any Nordic country [17, 19].

The fixed-term employment proportion was higher in Sweden than its neighboring Nordic countries, Finland, Norway, and Denmark, which respectively had 12%, 8%, and 7,% as shown in Figure 1 [14]. The combination of different types of fixed-term contracting coupled with employers' motivation to adjust their workforces in more flexible ways contributed to weaker labor market attachment among workers, thus to the rise of various forms of NSWA and PE conditions [17]. All these changes have affected the well-known Swedish model, turning it into a less generous welfare system, which, together with a trend of falling unionization membership, have contributed to the precarization of the Swedish labor market [20, 21].

Figure 1. Fixed-term employment as a percentage of the total employed population in Denmark, Finland, Norway, and Sweden between 1995-2015

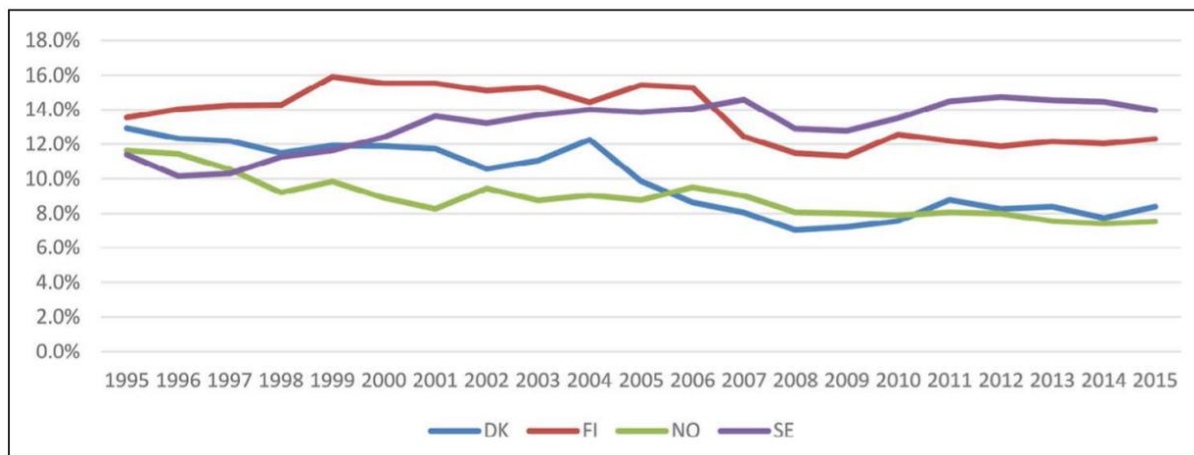


Figure originally published in Rasmussen et al. 2019, doi: 10.18291/njwls.v9iS6.114689, and is licensed under a Creative Commons Attribution 4.0 International License <https://creativecommons.org/licenses/by/4.0/>.

2.3 The development of precarious employment in Public Health research

Despite a wide variety of employment forms, SER remains the dominant form of employment relationship across all European countries [10]. Nevertheless, the speed of labor market changes, derived from megatrends' impact, has resulted in an increase in fixed-term contracting, involuntary part-time work, bogus self-employment, casual work, and informal work [10, 14]. Moreover, social systems and welfare provisions across the European Union (EU) are built upon SER, and an increased number of workers are excluded from welfare benefits and/or employment protection since their employment relationship does not fit the standard [10]. However, since there is no agreed and shared definition of what PE is, there is no single satisfactory depiction of this phenomenon.

Unidimensional approaches have been widely used to examine PE. However, such approaches are no longer considered state of the art as they do not capture the multidimensional nature of PE. Specifically, unidimensional approaches such as contract type, e.g., temporariness as a measure of employment instability, can result in exposure misclassification [22]. Interplaying a multidimensional construct allows examining levels of precariousness among workers beyond one characteristic of their employment relationship since any employment relationship (standard and non-standard) could include a precarious aspect and thus affect workers independently of contract type [22].

Researchers have developed numerous methods to define and measure PE throughout the years. Scholars have created proxy indicators using labor, economic, health, and social surveys. Some of the most used surveys are the European Working Conditions Survey, European Labour Force Survey, Gender and Generations Study in Belgium, Catalan Working Conditions Survey in Catalonia, the US General Social Survey, and Canadian Survey of Labor and Income Dynamics [23-29]. However, within Public Health research, only two validated questionnaires have been developed to measure PE as a multidimensional concept: the Employment Precariousness Scale (EPRES) in Barcelona [30] and the longitudinal survey Poverty and Employment Precarity in Southern Ontario (PEPSO) [31].

The EPRES scale includes six dimensions: “temporariness” (contract duration), “disempowerment” (level of negotiation of employment conditions), “vulnerability” (defenselessness to authoritarian treatment), “wages” (low or insufficient; possible economic deprivation), “rights” (such as paid vacations, parental leave, sick-leave benefits, and pensions), and “exercise rights” (powerlessness, in practice, not being able to exercise the workplace rights listed previously without obstacles) [30]. The Employment Precarious Index (PEPSO) was created based on ten questions covering: income level, income security, employment security, schedule predictability, contract type, employment-related benefits, fear of raising concerns at the workplace (lack of rights/vulnerability), and receiving salary in cash [31].

Survey-based scales have contributed to an increased understanding of PE and its associations with health [32-35]. Nevertheless, surveys are time-consuming and expensive, potentially limiting the possibility to repeat the measurements over time and follow individuals longitudinally [36]. Also, the falling response rates of surveys in healthcare epidemiology to 20-30% can include a non-representative sample [36, 37]. Furthermore, the cross-sectional nature of these studies limits the understanding of PE, especially when trying to study how this phenomenon develops over the years, which is not possible when using only one time-point measurement since it does not count for reverse causation or health selection effects.

Overall, these aspects have hampered the understanding of PE as an occupational exposure and challenge comparison between studies and investigation of the possible associations with OIs.

2.4 Occupational injuries and under-reporting

Workplace injuries pose a significant human, social, and economic burden on individuals and society [38]. The social consequences of an OI go far beyond the injured worker. An OI can affect family members, co-workers, the health care system, the employer (loss of productivity), and society [39]. The European Agency for Safety and Health at Work estimated that the burden of OI and diseases is 3.9% of global gross domestic product (GDP) and 3.3% of the European GDP [40]. While fatal injuries have declined in the last decades, non-fatal injuries have increased by 6.4% between 2012 and 2018 [41]. Furthermore, 3.1 million non-fatal workplace injuries in the EU result in at least four days of sickness absence per injured worker [41]. A distribution of workplace injuries according to economic activity and sickness absence is shown in Figure 2 below, where it is possible to notice how injuries resulting in absence from work up to one month count for approximately 60% of the total injuries.

Figure 2. Percentage of accidents at work by severity for each economic activity among the EU-27 IN 2018

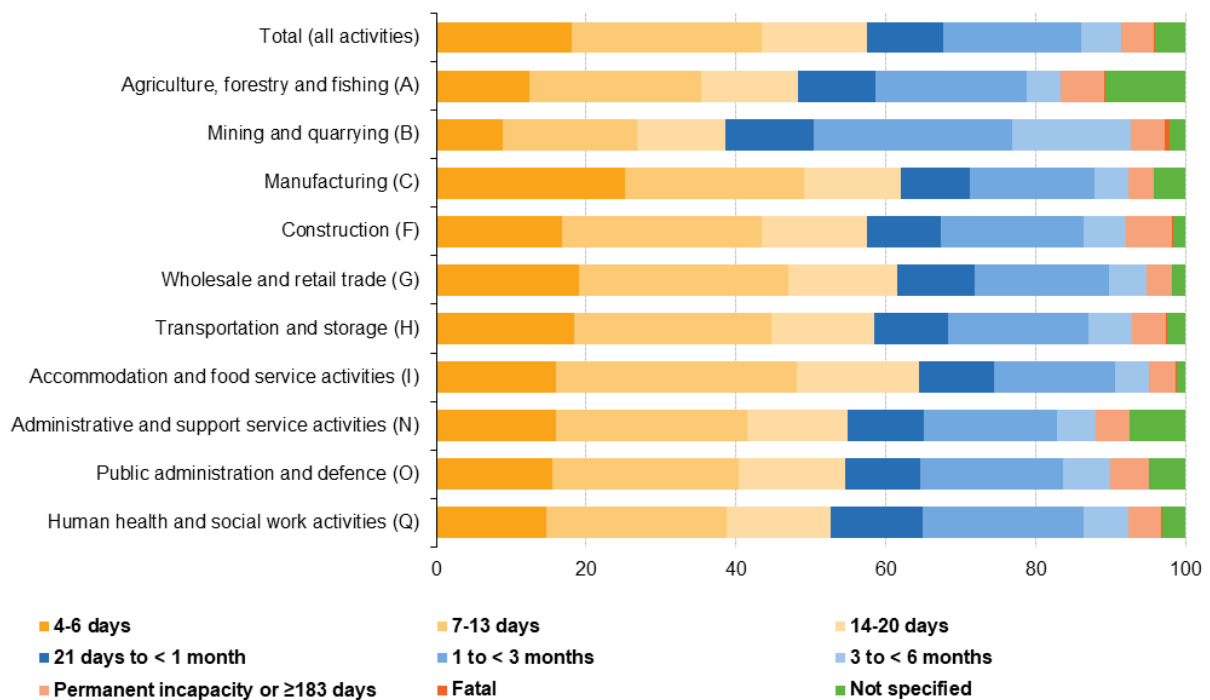


Figure originally published by Eurostat in “Accidents at work - statistics by economic activity” in 2018 and licensed under a Creative Commons Attribution 4.0 International License <https://creativecommons.org/licenses/by/4.0/>.

Across all the economic sectors in the EU, one of the most common body parts injured at work was the back, accounting for 11.3% of all non-fatal OIs, while 39.3% of the total number of non-fatal OIs resulted in an injury of the upper extremities (shoulders, arms, and hands), and 28.7% resulted in injuring the lower extremities (hips, legs, and feet) [41]. When focusing on the type of injury, the most commonly reported were: wounds and superficial injuries (29.3%); dislocations, sprains and strains (26.4%); concussion and internal injuries (19.1%), and bone fractures (10.7%) [41].

Overall, men in the EU were more likely to have an OI than women, with two out of three non-fatal OIs involving male workers [41]. Type of work and economic sector may partially explain this gender difference among the EU-27 countries, with the incidence of OIs being higher in male-dominated sectors (manufacturing, construction, agriculture, forestry, and fishing). Furthermore, age was another factor related to OIs: 12% of all non-fatal OIs in 2018 involved young workers under 25 years of age, while 17% involved workers above 55 years of age [41]. The percentage among young adults was higher among economic sectors known to employ higher shares of young workers, such as manufacturing (12.3%), construction (13.1%), administrative and support service (14.8%), wholesale and retail (15.6%), and accommodation and food service (23%) [41]. On the other hand, older workers in the EU reported higher incidences of OIs across the following economic sectors: in the transportation and storage (18.2%), human health and social work (20.8%), public administration and defense (24.4%), agriculture, forestry and fishing (25.7%) [41].

Sweden reported 1094 non-fatal OIs per 100000 workers in 2016, lower than its neighboring countries Denmark and Finland (respectively 1794 and 1726 per 100000 workers), but higher than Norway (398 per 100000 workers) [42]. Thorough national reports on OIs statistics are redacted and monitored yearly in Sweden by Statistics Sweden (Arbetsmilöverket). In 2020 approximately 33000 work-place injuries resulting in sick leave were reported among workers and self-employed in Sweden [43]. Figure 3 shows the higher number reported by men compared to women (respectively 18200 and 14800). These injuries corresponded to 7.0 occupational injuries leading to sick leave per 1000 employed men, while 6.1 cases per 1000 employed women. When considering age, young men (aged 16-24) had the highest number of OIs with sick leave compared to other ages.

Figure 3. OIs leading to sick leave per 1000 employed individuals by age group and gender in 2020 in Sweden.

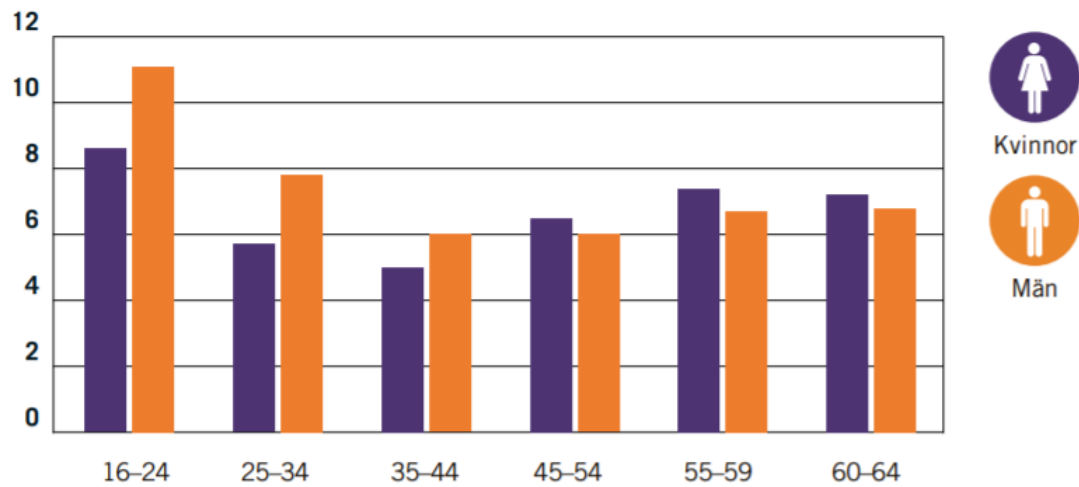


Figure originally published by Statistics Sweden (Arbetsmilöverket) 2020, Arbetsmiljöstatistik Rapport 2021:01, and is licensed under a Creative Commons Attribution 4.0 International License <https://creativecommons.org/licenses/by/4.0/>.

On the other hand, there were 61,400 occupational work-place injuries that did not lead to any day of absence from work, which corresponded to approximately 12.5 cases per 1000 employed persons (Figure 4) [43]. Unlikely in injuries leading to sick leave, women were over-represented in this category with 20 cases per 1000 employed persons. Here, once again the youngest group was found to have highest number of injuries.

Figure 4. OIs without sick leave per 1000 employed individuals by age group and gender in 2020 in Sweden.

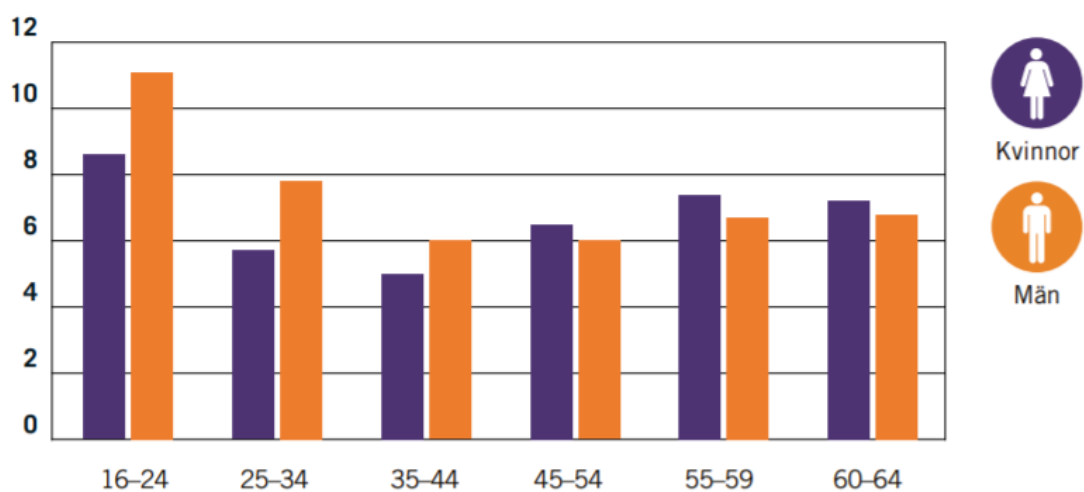


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Nevertheless, such reports tend to be descriptive with little attention to how changes in employment arrangements and new ways of organizing work could increase workplace injuries across specific groups of workers, such as those in PE. Moreover, although national surveys and reports are performed regularly across most countries, the level of under-reporting is not taken into account and remains largely unquantified. Studies have found an estimated range of 29% to 81% of OIs are under-reported [38, 44-48].

Researchers have adopted different approaches and techniques to measure the extent of under-reporting, such as inflating incidence rates by comparing epidemiological studies with compensations estimates [49] or performing work injury surveys and/or comparing the results with the accepted compensations claims or reported injuries [50]. A study conducted across the Baltic region (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Northwest Russia, Norway, Poland, and Sweden) used an exploratory approach to provide an estimate of under-reporting of non-fatal OIs [51]. The study multiplied the number of injuries of each country by an external coefficient of a benchmark country (Finland and Germany). More specifically, the incidence rate of non-fatal OIs of the benchmark country was compared to the reported numbers of each of the other countries. This has been the only attempt to measure under-reporting levels across multiple countries in Europe. Reliable and accurate statistics are essential for effective injury prevention programs and suitable policy measures.

Nevertheless, there has been very little research on monitoring OIs among precarious workers. Quantifying and monitoring the possible impact of a new exposure such as PE to known occupational risk factors becomes fundamental if we want to avoid reinforcing prevailing inequalities in our society and consequently achieve the United Nations 2030 Sustainable Development Goals (SDGs) n. 3 and 8 aim respectively at ensuring healthy lives and decent work for all people [52].

2.4.1 Occupational injuries and precarious employment

Several factors have been associated with an increased risk of OIs, such as sociodemographic factors (younger age, male gender, low educational attainment, migration status) [53-55], exposure to long working hours and job insecurity [56, 57], job stress and highly demanding physical and mental workloads, hazardous worksite conditions, lack of in-job training and protective equipment [58-60]. In addition, workers presenting comorbidities as chronic heart diseases, diabetes, depression, etc., or with low workability scores, have also been shown to have an increased risk of OIs [61].

Despite PE being an acknowledged social determinant of health and inequalities, the relationship between PE and OI has often been overlooked. Thus, knowledge of the pathways and mechanisms by which PE can affect OIs remains incomplete. Some of the challenges are that PE relationships result in a heterogeneous workforce that creates barriers to examining how different employment arrangements affect the risk of workplace injuries for precarious and non-precarious workers performing the same job tasks.

Early explorations in the 1990's, reported an increased risk of OIs among temporary workers [62-65]. Similarly, agency workers had an increased risk of workplace injuries than workers with standard employment [66]. In 2018, Koryani et al. performed a systematic review that analyzed the relationship between PE and OIs, focusing on length of employment, work characteristics, income, and labor rights [67]. Workers in multiple jobs and those employed by temporary agencies had an increased risk of OIs [68, 69]. Contrary to previous studies, the systematic review found no associations between temporary workers and increased risk of OIs [70, 71]. Previous studies have found that unionized workers have an increased risk of OIs [72, 73]. Such associations may be mediated by a combination of better reporting systems and awareness in unionized workplaces, higher incentives for reporting as workers' compensation can be linked to unionization, and lastly that the most hazardous workplaces are more likely to be unionized [72, 73].

Some potential reasons affecting the risk of OIs of precarious workers from those standardly employed have been proposed in the literature. First, precariously employed workers may not receive the same in-job training or protective equipment as those in standard employment, resulting in a different perception of the safety practices involved in their employment and confusion over who bears responsibility for workplace safety [74-76].

Second, precarious workers may be assigned to more hazardous job tasks and may be deterred from refusing because of their employment's temporary and insecure nature [77-80].

Last, higher rates of presenteeism have been found among workers in PE [81]. Finally, presenteeism among precarious workers may be driven by a lack of access to sick leave benefits, which can, in turn, increase the risk of OIs by working in poor health [82].

While studies have demonstrated differential health risks between PE and a set of health outcomes, an understanding of how PE affects OIs remains incomplete. Thus, to ensure the health and wellbeing of all workers regardless of their employment arrangement, it is crucial investigating possible associations between PE and OIs. This thesis aims at fulfilling this knowledge gap.

3 AIMS AND RESEARCH QUESTIONS

The overarching aim of this thesis was two-fold:

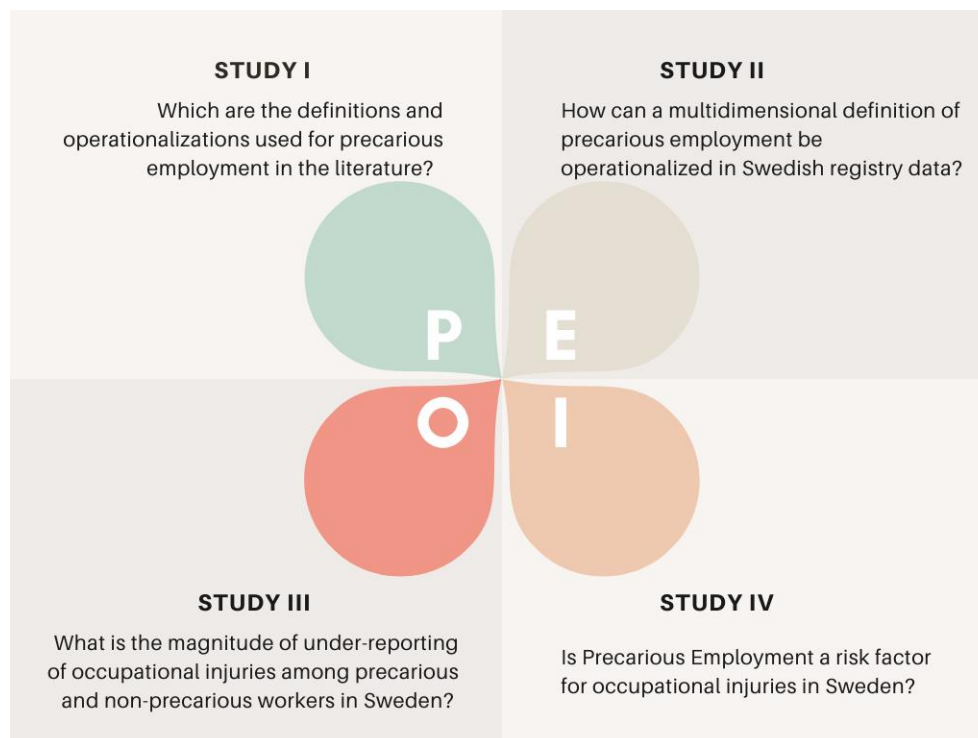
1. to advance the understanding and development of PE as an occupational exposure and
2. investigate its relation to under-reporting levels of OIs and risks of OIs among the precarious and non-precarious working population in Sweden.

The following specific aims were investigated to fulfill the aim of the thesis:

- I. To investigate how PE has been defined within research by reviewing the literature for definitions and operationalizations of PE and identify the construct's core dimensions to facilitate guidance on its operationalization. (Study I)
- II. To develop and explore multidimensional operationalizations of PE in Swedish register data. (Study II)
- III. To estimate the magnitude of under-reporting of OIs among employed workers in Sweden in 2013 according to the level of employment precariousness. (Study III)
- IV. To investigate PE as a risk factor for OIs in Sweden. (Study IV)

An overview of the research questions is presented in Figure 5.

Figure 5. Research questions in Study I-IV



4 METHODS

To advance the understanding and methodological development of PE as a multidimensional construct, Study I and II were developed to fulfill the first aim of the thesis. The three dimensions and nine items of PE identified in Study I were used to the SWE-ROPE in Study II both as a summative scale and a typological approach. The summative scale approach was later used in Study III and IV to investigate the level of under-reporting of OIs among precarious and non-precarious workers and whether PE is a risk OIs in Sweden. A methodological summary is presented in Figure 6.

Figure 6. Methodological summary of Study I-IV

	Aim	Study Design, Population	Exposure, Outcome	Analysis
Study I	Investigate definitions and operationalizations of PE in the literature	Systematic review, N/A	N/A	Descriptive, Thematic Analysis
Study II	Operationalize PE through a typological and summative scale approach	Cross-sectional; Working population in Sweden	Employment typology and summative scale score; N/A	Latent Class analysis, Descriptive
Study III	Estimate under-reporting of OIs among precarious and non-precarious workers	Cross-sectional; Working population in Sweden with at least an OI	PE score; N. of under-reported OIs	Two-sources capture-recapture analysis
Study IV	Investigate PE as a risk factor for OIs	Open cohort; Working population in Sweden	PE score and PE dimensions; Injured/not injured	Pooled multivariate logistic regression

4.1 Study design and study population

Different study designs characterize the studies in this thesis. Study I was designed to systematically review the available definitions and operationalization of PE in the literature. The review was extended to a variety of scientific disciplines and methodologies. Only original and peer-reviewed publications in English that included an explicit definition or operationalization of PE were included in the review. No restrictions were applied on the year of publication, population, or research discipline.

Study II was designed as a cross-sectional/methodological study and used Study I as a conceptual framework. The aim was to explore multidimensional operationalizations of PE in Swedish register data using a typological approach and a summative scale approach over one year. Study participants were included if they were alive and officially residing in Sweden, between 18 to 65 years of age, had a minimum of one employer, and a registered working income of >100 Swedish Krona (SEK) in 2014. Individuals that died emigrated or immigrated during the year were excluded from the study. In addition, two years prior to the year of interest were included to operationalize PE (thus 2012 and 2013). The final study population for 2014 was 4.349.322.

Using the summative scale approach developed in Study II, Study III aimed at estimating the magnitude of underreporting of OIs among employed workers in Sweden according to the level of PE in 2013. Data on the outcome, OIs, were available for only one year (2013) in one of the registers; therefore, the study has a cross-sectional design. The study participants were selected accordingly to the criteria described for Study II, but with an additional inclusion criterion: only individuals who had a probability higher than 90% that the employer paid occupational pension were included. This criterion was deemed necessary to have a baseline population having the same probability of being captured by both OI registers. In addition, while one of the registers includes all injured employees in Sweden, the other includes only injured individuals whose employer pays insurance fees.

This determined the exclusion of all self-employed persons from the study and individuals working for small companies (<10 employees). Therefore, we could not operationalize the last dimension of the PE construct, lack of rights and protection, since individuals likely to be covered less than 90% by collective bargaining agreement in the organization of employment were excluded. Since injured individuals were the subjects in this study, the final population included 82949 unique OIs.

Last, after estimating the magnitude of under-reporting according to the level of precariousness, Study IV of this thesis aimed at investigating if precarious workers were at higher risk of OIs compared to non-precarious workers. This study was designed as a repeated prospective study where individuals could contribute to multiple years from 2006 to 2014. The baseline for each individual was defined as the person's first appearance in the cohort. The study participants were selected accordingly to the criteria described for Study II, with a few extra divergences: i) self-employed were excluded to avoid misclassification of such workers as precarious workers; ii) unemployment spells during any year were excluded to account for time-at risk. In this study, the exposure was measured at baseline (first appearance in the cohort) and the outcome during the following year to account for reverse causality (e.g., PE measured in 2010 and whether having an OI in 2011). Additionally, results from Study III were incorporated to take into account potential bias due to under-reporting among precarious employees. This open-cohort study included 4,794,584 unique individuals during the whole study period.

4.2 Data sources

Study I is based on screening two multidisciplinary bibliographic databases, Web of Knowledge and Scopus. Study II, III, and IV were performed using a set of Swedish registries from which sociodemographic information and information necessary to measure exposure and outcome were extracted. Details of these data sources are presented in the following sections.

4.2.1 Web of Knowledge and Scopus

Two multidisciplinary bibliographic databases were used as data sources in Study I to retrieve bibliographic information, author abstracts, and full-text articles of peer-reviewed literature:

- a) Web of knowledge is an online database that provides access to a range of online scientific databases and resources, such as Web of Science, Medline, social sciences databases, etc. [83].
- b) Scopus is one of the largest and most comprehensive online databases, including peer-reviewed literature from various scientific fields of science, technology, medicine, social sciences, and arts and humanities [84].

4.2.2 Swedish registries

As mentioned in the earlier section, Study II, III, and IV were register-based studies for which a combination of five different Swedish registries was used to extract information on the working population in Sweden between 2003 and 2014. Linkage across the registries was possible thanks to the unique personal identification number assigned to each resident in Sweden and allows pooling information from different data sources on an individual level [85]. This linkage is conducted by Statistics Sweden who replaced all identity numbers with random serial numbers to ensure anonymity. A description of each of the registries follows:

- a) The longitudinal integration database for health insurance and labor market studies (LISA) is a register held by Statistics Sweden, including information on each individual above 15 years of age officially residing in Sweden as of the 31st December of each year. LISA is a population register that contains individual-level information on demography, education, employment, unemployment, income, social insurance, etc., deriving from various sources [86]. In addition, this rich information allows obtaining detailed information about their workplace (worksite, occupation, economic sector), immigration, and emigration.
- b) The cause of death register (DR) includes registered individuals in Sweden who died during one calendar year, regardless of whether the death occurred within or outside Sweden [87]. The death is registered in the system by the physician no later than three weeks after the event, and the registry provides information on the underlying cause of the death, which is coded according to the international version of the Swedish International Classification of Disease (ICD-10 classification) [87].

- c) The national patient register (NPR) is held by the National Board of Health and Welfare and covers each individual registered in Sweden since 1987 [88]. The registry includes sociodemographic data on patients (gender, age, place of residence, etc.), medical data (primary and secondary diagnoses, external causes of injuries, etc.), and administrative data (date of admission or discharge). Diagnoses are coded according to ICD-10, including information on inpatient and specialized outpatient care [89].
- d) The Swedish information system on occupational accidents and work-related diseases (ISA) was initiated in 1979 by the National Board of Occupational Safety and Health authority (as from 2001 the Swedish Work Environment Authority) [90]. In order for an occupational accident or work-related disease to be included in ISA, a report must have been made by the injured employee to the employer (or work supervisor) and consequently by the employer to the Social Insurance Agency, which covers all economically active persons, employees, employers and self-employed [90]. The Insurance Agency examines all reports received and assesses whether the worker is entitled to compensation. The National Board of Occupational Safety and Health covers any injury that has been reported to the Social Insurance Agency, regardless of their eligibility for compensation.
- e) AFA Insurance is a mutual insurance fund owned and managed by Sweden's labor market parties: the Confederation of Swedish Enterprise, the Swedish Trade Union Confederation (LO), and The Council for Negotiation and Co-operation (PTK) since 1963. AFA provides financial support in the event of incapacity for work due to sickness, work injury, shortage of work, death, and parental leave [91]. Each individual is covered by an agreement via their job, and the Compensation for personal injury agreement board decides if a person is entitled to compensation. In addition, AFA insurance provides information (sociodemographic, employment, financial, health, and injuries data) of each individual to whom the claim for an occupational injury has been granted [91].

4.3 Exposure assessment

A first step towards measuring PE in Sweden was to investigate how this concept was defined and operationalized in the literature and identify common characteristics which would serve as central dimensions of PE (Study I). Such dimensions would then facilitate the operationalization of PE using Swedish registries (Study II).

4.3.1 Systematic review of precarious employment in the literature

A systematic review of quantitative and qualitative studies was performed across disciplines to review PE's definitions and operationalizations in the literature (Study I). Two main multidisciplinary databases were screened for eligible studies: Web of Knowledge and Scopus. The search strategy was conducted using the same keywords in both databases and included a spectrum of terms all strictly related to "precarious employment". Only original publications were included in the review, while literature in English and did not include an explicit definition or operationalization of PE were excluded.

First, quantitative data on study characteristics were extracted from the articles such as country of study, research area, study design, main outcomes, definition, and/or measurement of PE. Then, thematic analysis was used to identify patterned meanings across the collected data and generate dimensions of PE.

4.3.2 Operationalization of precarious employment

Building upon the findings from Study I, a multidimensional operationalization of PE was created upon the dimensions identified by the systematic review. Precisely, three dimensions and five items were measured in the SWE-ROPE using data extracted from the LISA register as displayed in Table 1. SWE-ROPE was constructed using both a summative scale approach and a typological approach. After that, only the summative scale approach was used in Study III and IV to investigate under-reporting and risks of OIs, since the main aim was to investigate specifically precarious workers and not employment quality typologies.

Table 1. Register-based Operationalization of precarious employment, Study II

Dimension	Theme	Item specification	Operationalization
Employment Insecurity	Contractual relationship insecurity	(1) Directly employed by employer	(1) Employed directly by employer, and not being identified by 2-5 below
		(2) Employed by an agency	(2) Employed directly by employer, with workplace activity “Temporary employment agency activities” (SNI-code=78.2).
		(3) Self-employed and employed	(3) Employed and self-employed in combination
	Contractual temporariness	(4) Self-employed	(4) Self-employed, self-employed in corporation, number of employees >1
		(5) Solo self-employed	(5) Self-employed, self-employed in corporation, number of employees = 1
		(1) Stable employment	(1) Having the same employer for 3 consecutive years
	Multiple jobs/sectors	(2) Unstable employment	(2) Having the same employer for <3 years
		(1) One job (employer) during the year	(1) 1-2 employers in 1-2 economic sector ^a
		(2) Multiple jobs	(2) ≥3 employers in 1-2 economic sector ^a
	Income level	(3) Multiple jobs in multiple sectors	(3) ≥3 employers in >3 economic sector ^b
		Income level (before taxes) in relation to the median of the population	(1) ≥200% of the median ^c
			(2) 120-199% of the median ^d
Income Inadequacy	Lack of unionization		(3) 80-119% of the median ^e
			(4) 60-79% of the median ^f
			(5) <60% of the median ^g
Lack of rights and protection	Lack of unionization	Likelihood of being covered by collective bargaining agreement in the organization of employment	(1) >90%
			(2) 71-90%
			(3) ≤70%

a. Operationalized by adding up the number of unique employers during the year, i.e., the reference employer, primary, secondary and tertiary employer

b. Economic sector grouped in 10 categories: agriculture, commerce and hospitality, construction, education, financial services, health, industry, other services, public administration, transport.

c-g. >200% = >650 800 SEK; 120-199% = 390 480-650 800 SEK; 80-119% = 260 320-390 480 SEK; 60-79% = 195 240-260 320 SEK; and <60% = 100-195 240 SEK.

Table modified from its original version, originally published in Jonsson et al. 2021, doi: 10.5271/sjweh.3928, and is licensed under a Creative Commons Attribution 4.0 International License <https://creativecommons.org/licenses/by/4.0/>.

4.3.2.1 The precarious employment score

After translating the items of PE using information derived from the LISA register, each item was scored on a scale from -2 to +2 for the year 2014. In this summative scale, positive values were introduced only for the income dimension (for higher income than the median) to avoid possible misclassification derived from high-income salaries. The sum of the score of each item resulted in a summative score, and similarly to other operationalizations, no weighting was introduced in the scoring. Since SER is considered the golden standard of the employment relationship, each item was scored based on their deviation from SER.

Therefore, individuals that were directly employed had stable employment (measured as having the same employer for more than two years), had no multiple jobs, an income above 81% of the median, and >90% of the probability to be covered by collective bargaining agreement were scored with 0 or above (Table 2). This group was considered non-precarious workers in Study II, III, and IV. When the summative score was operationalized in Study III, individuals scoring ≤ -3 were considered the precarious population since they represented the 25th percentile of the total population.

Table 2. Scoring of items of precarious employment, Study II

Item	Score				
	-2	-1	0	1	2
Contractual relationship insecurity	Solo self-employed	Self-employed and employed Self-employed Agency employed	Directly employed		
Contractual temporariness	Unstable employment		Stable employment		
Multiple jobs/economic sectors	≥ 3 jobs in >3 sectors	≥ 3 jobs in 1-2 sectors	1-2 jobs in 1-2 sectors		
Income	<60%	60-79%	80-119%	120-199%	$\geq 200\%$
Likelihood of CBA-coverage	$\leq 70\%$	71-90%	90-100%		

CBA: Collective Bargaining Agreement

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The SWE-ROPE was later updated to reduce misclassification, and workers scoring ≤ -4 were considered precarious. This later version was used in Study IV. It is important to note that the change in the cut-off for workers to be considered precarious did not affect the overall distribution of individuals across the summative score scale. However, a small proportion of the precarious population (approximately 2%) moved to the 'middle group' defined as the "borderline precarious group" in Study III or the "middle group" in Study 4. This mid-group lying in between the precarious and non-precarious group is a heterogeneous group of workers whose characteristics resemble NSW, e.g., agency employed or multiple job holders with unstable employment, and either low/middle income or low/mid probability to be covered by collective bargaining agreement (CBA).

4.3.2.2 The Employment typologies

Alongside the summative score approach, LCA was performed in Study II to identify employment typologies. This methodology allowed the creation of mutually exclusive and exhaustive classes (named in this thesis as employment types) to which each individual was assigned for the year 2014. Individuals were assigned to such classes based on the observation of categorical data that were used to estimate groups of individuals with similar response patterns [92]. The interpretation and labels of the classes were based on the parameters produced by the LCA model: the average posterior probabilities (AVEPP), which is the probability of membership in each latent class; and the conditional item-response probabilities, which is the probability of each item-response conditional on each of the latent classes [93]. After this process, six employment types were derived from the final six-classes model: Standard Employment Relationship (SER), Business Owners (BO), Proficians, Precarious Employment Relationship (PER), Precarious Self-employment and Precarious Multiple Job Holders. These six employment types were consequently labeled based on their main defining characteristics in each class. Such characteristics were complemented with sociodemographic characteristics, such as age, sex, education, occupation, economic sector, and country of birth, known to be axes of inequality in PE [22].

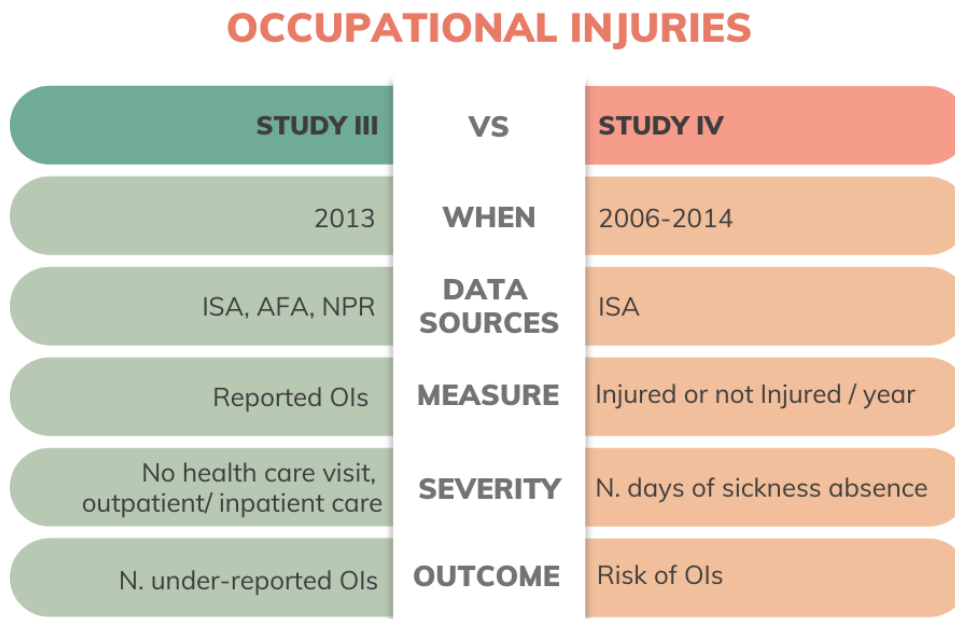
4.4 Outcome assessment

The primary health outcome of this thesis was OIs. Throughout Study III and IV, OIs were defined by Swedish legal definition as “*an injury due to accident(s), which occurred at the workplace or other place where the injured person had been for work. For an event to be counted as an accident, it is required that the course was relatively short and arose in connection with a particular event*” [94]. Only non-fatal OIs were investigated in this thesis. The small number of incidences drove the decision to exclude fatal injuries (<50 per year). Moreover, in the case of a fatal injury, the exposure could not be assessed as these individuals did not have available register data on the same year as their death. Furthermore, occupational diseases, defined as “*any disease contracted as a result of an exposure to risk factors arising from work activity*” [95], were also excluded from this thesis, being the main aim specifically that of investigating PE and workplace injuries. Injuries that occurred during transit to/from work were also excluded from the studies since they are collected by a different register and are categorized as traffic injuries.

In study III several steps were conducted to estimate the under-reporting of OIs. First, OIs in ISA and AFA were linked based on a ± 7 days range, with injuries reported within a week in either of them considered the same workplace injury. As sickness absence was not harmonized between these two data sources, severity was added from the NPR and linked to the ISA/AFA information, following once again ± 7 days range. Injury severity was categorized according to three levels of increasing OIs severity: a) no healthcare (no admission in NPR), b) outpatient care, and c) hospitalization. All injuries, independent of their severity level, were included in the analysis.

In study IV, OIs were initially categorized based on sickness absence (obtained from the ISA register) as a) no sickness absence from work, b) between 1 and 3 days of sickness absence, c) between 4 and 14 days of sickness absence, and d) more than 14 days of sickness absence. Then OIs were dichotomized into individuals who had an OI and individuals who did not present an OI for each year between 2006 and 2014. Finally, if an individual reported multiple OIs during the same year, the most severe was kept (i.e., the OI that led to most days of sickness absence as these are less frequently under-reported). Figure 7 provides an overview of how OIs were operationalized in Study III and IV.

Figure 7. Overview of the operationalization of OIs in Study III-IV



4.5 Additional variables and confounding factors

Additional variables and confounders were considered in the analyses for Study II, III, and IV. Confounding factors were selected based on Direct Acyclic Graphs (DAGs), where a set of minimal and sufficient adjustments are chosen [96].

The following descriptive variables were included with a small variation across the studies: sex, age, education, country of birth, family composition, studying during the year, occupation, economic sector, ownership sector. Covariates adjusted models including sex, age and country of birth were run in Study III and IV. Since crude models were in close agreement with adjusted models, only crude models were included in study III. Both crude and adjusted models were presented in study IV.

4.6 Analytical approach

To structure and analyze definitions and operationalizations of PE in the literature, both quantitative and qualitative analyses were performed in Study I. First, summary statistics of the study characteristics were extracted, including information on region, research area, study design, primary outcome of the studies, type of PE definitions, and number of PE dimensions. Afterward, thematic analysis was performed to analyze underlying patterns across definitions and operationalizations of PE in the literature and create dimensions of PE with specific subthemes (or items) [97]. Three main steps were performed that, at times, overlapped: i) subthemes were created after a free line-by-line analysis of each definition or measurement of PE; ii) aggregated themes were further developed by grouping subthemes in broader patterns of meanings; iii) themes were clustered into dimensions of PE. Thematic analysis allowed the creation of new theoretical understanding of PE through the analysis of patterns in the data (e.g., common measurements across the studies), but it also allowed identifying gaps (e.g., no study looking at income volatility).

Study II used both a summative scale and a typological approach to operationalize PE. The summative score was created for each individual included in the study. To construct the employment typologies in 2014, multiple LCA were performed on the included population for men and women separately and with and without students. Consequently, cross-tabulations and average summative scale scores were conducted to identify specific characteristics at the individual and organizational levels. Finally, the proportion of each employment type falling beneath the 25th percentile of the summative score was calculated to define the precarious share across the employment typologies.

A two-source capture-recapture analysis was performed to estimate the under-reporting level across precarious and non-precarious workers in Study III. By combining the reported injuries in both ISA and AFA databases and using the Lincoln-Peterson estimator that assumes source independence [98], the total number of OIs was estimated.

This estimate included injuries that were not reported to either ISA or AFA. The under-reporting estimates were then computed separately for the sociodemographic characteristics, occupations, severity level, PE scoring levels (precarious, borderline precarious, non-precarious workers), and the two dimensions of PE. Finally, adjusted models were calculated using log-linear regression models [99].

To investigate PE as a risk factor for OIs in study IV, both crude and adjusted Odds Ratios (OR) estimates with 95% confidence intervals (CIs) were calculated in a pooled multivariate logistic regression stratified by sex for the years 2006-2014 [100]. When the outcome is rare (typically <10%) OR and risk ratios can be used interchangeably since their values do not differ much [101]. Thus, since over 90% of workers in Sweden do not present an OI, ORs in this study can be interpreted as risk ratios. To account for reverse causation, we considered the exposure the year before the outcome, and we further adjusted for previous OIs since we do not know if injuries may lead an individual to be more precarious in the labor market. Two approaches were adopted to define the exposure: in the first, PE was operationalized using the SWE-ROPE summative scale, which resulted in three precarious groups (precarious, “middle group,” and non-precarious); in the second, each item of PE was considered an exposure in the model (contract insecurity, contractual temporariness, multiple jobs/sectors, income level, CBA). In addition, six sensitivity analyses were performed to further dig into possible mechanisms affecting the relationship between the exposure and outcome. Further details can be found in study IV, such as accounting for under-reporting of OIs and injury severity (absence from work) and economic sector.

Data management was performed with SAS, version 9.4 (SAS Institute, Cary, NC, USA) for all register-based studies, as well as the multivariate analysis in study IV, LCA modeling in study II was performed using Mplus version 8.4. The capture-recapture analysis in study III was performed using R (R Foundation for Statistical Computing).

4.7 Ethical consideration

There are specific ethical considerations to take into account when performing register-based research in terms of collecting and storing sensitive data and weighing the potential harm of research persons against the benefits of research. In this thesis, there was no direct involvement of study participants hence no individual consent was needed. Nevertheless, it is crucial to ensure the anonymity of the data. Therefore, Statistics Sweden replaces the unique personal identification number with a random serial number prior to the data being delivered to researchers. Thus, no researcher has access to sensitive information or does not have any possibility to track back the original identifier. The anonymized data are thereafter stored on password-protected servers of Karolinska Institutet (SecureLan).

Furthermore, all data were presented on a group level for the whole working population of Sweden to prevent any risk of single individuals being identified. Finally, while no study participant is put at any immediate risk when performing the studies, using extensive data to characterize the precarious working population in Sweden is a first step towards better identifying this dynamic population in the labor market and addressing potential health and social consequences that can ultimately benefit precarious workers and society at large. All studies in this thesis were approved by the Regional Ethics Board of Stockholm with no. 2016/2325-31.

5 RESULTS

5.1 From definitions of precarious employment to the SWE-ROPE (Study I, II)

The systematic review of the 63 research articles included in Study I showed how PE was defined and measured across different scientific disciplines. After identifying the study characteristics, the thematic analysis of the definitions resulted in three overarching dimensions and nine items of PE (Figure 8): employment insecurity, income inadequacy, and lack of rights and protection. Besides the variety in definitions and operationalizations of PE, the measurement of this concept across the studies was predominantly driven by data-availability, which reflected the high heterogeneity in the measurement of each of the items characterizing the dimensions. The majority of the studies defined PE based on contractual status: among 145 subthemes extracted from the analyzed definitions, 73 focused on one of the contractual aspects of PE (e.g., directly employed versus agency employed or self-employed, short-term versus permanent contracting, part-time versus full-time, having one job versus multiple jobs).

Figure 8. Dimensions and themes, Study I

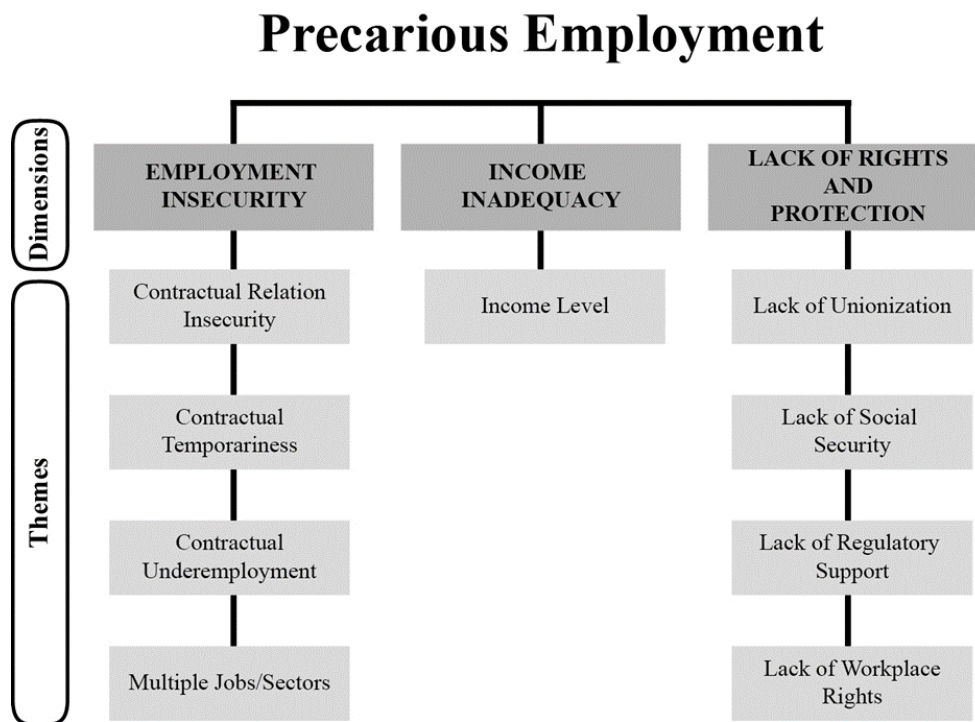


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After identifying the dimensions and items of Study I, PE was operationalized as a summative scale score and a typological approach using register-based data. The summative approach resulted in a scale where an individual could score between -10 to +2, with an average of -1.8 in 2014. A lower score was associated with solo self-employment, agency employment, unstable employment, multiple jobholders in multiple sectors, poor income, and poor CBA coverage.

As to the typological approach, the LCA analysis resulted in six employment types, of which three were considered precarious (PER, self-employed, precarious multiple jobholders). The PER-type accounted for 22% of the overall sample and was overrepresented among agency employed, unstable employment, multiple job holders working in multiple sectors, and those with poor income (Table 3).

Table 3. Description of employment types and summative scale score averages, Study II

Employment type	Employment characteristics	Size (%)	Average score	Low scores (%)^a
PER	Direct or agency-employment, unstable employment, one job or multiple jobs/sectors, poor income, moderate to high CBA-coverage	22	-4.7	81.5
Precarious multiple jobholders	Combination employment, multiple jobs/sectors, poor-median income, low CBA-coverage	2	-6.1	95.7
Precarious self-employed	Solo self-employment, mainly stable employment, one job, poor income, poor CBA-coverage	5	-4.9	80.4
Proficians	Direct- or combination-employment, stable or unstable employment, multiple jobs/sectors, high income, high CBA-coverage	10	-2.0	11.8
BO	Self-employment with employees, stable employment, one job, median-high income, moderate CBA-coverage	2	-1.9	5.3
SER	Direct and stable employment, one job, median income, high CBA-coverage	60	-0.3	0.4

a. Scores beneath the 25th percentile (score of -4) of the total summative scale score distribution
 PER=Precarious Employment Relationship; BO= Business Ownership; SER= Standard Employment Relationship

5.2 Under-reporting level of OIs among precarious and non-precarious workers (study III)

The magnitude of under-reporting was 50% higher among precariously employed workers compared to non-precarious workers, and the analysis estimated 13522 under-reported OIs in Sweden for the year 2013. Under-reporting followed a dose-response pattern where a higher level of precariousness was associated with increased under-reporting.

Specifically, precarious workers presented a 22.6% of under-reporting (95%CI 21.3% to 23.8%), followed by borderline precarious workers with a 17.6% of under-reporting (95%CI 17.1% to 18.2%) and lastly, non-precarious workers with a 15.0% of under-reporting (95%CI 14.7% to 15.3%). When considering under-reporting levels according to sociodemographic characteristics, female workers and younger workers had higher under-reporting injuries than male and older workers. Among occupations, a higher under-reporting was observed among precarious and border-line precarious workers than non-precarious workers. Nevertheless, not all findings were statistically significant. Ultimately, under-reporting levels decreased with increased injury severity (no healthcare, outpatient care, hospitalization), with the precarious group presenting the highest estimates across all severities. A separate analysis was performed on under-reporting levels according to four items of the first two dimensions of PE included in study II (employment insecurity and income inadequacy). In the employment insecurity dimension, under-reporting levels were higher among workers holding an unstable position and workers with multiple jobs. In the income dimension, estimates were higher for individuals earning above >200% of the median and those earning below 60% of the median. More details on under-reporting levels can be found in Study III at the end of the thesis.

5.3 Precarious employment as a risk factor for OIs (study IV)

To look at PE as a risk factor for OIs in Sweden between 2006 and 2014, two approaches were adopted in terms of exposure. The first model adopted the PE score, and both crude and adjusted models showed precarious workers having a decreased risk of OIs compared to non-precarious workers (OR<1). To confirm these results, a set of sensitivity analyses were run. The results did not change when weighting for under-reporting levels, stratifying by occupation, economic sector, and injury severity (defined as injuries that lead to absence from work). The second model was stratified by sex, and crude and adjusted results were shown for each dimension of PE. Specifically, male workers employed through agencies had a higher risk of OIs (OR 1.19 CI 1.15-1.23), as did both male and female workers in multiple jobs/sectors (OR 1.25 CI 1.23-1.28 and OR 1.10 CI 1.07-1.13 respectively), as well as women workers in the low-income groups (OR 1.11 CI 1.09-1.12).

6 DISCUSSION

6.1 Key findings

This thesis can be framed as part of a large research project aimed at advancing the research on PE as a multidimensional construct and occupational exposure in the Swedish context and the international one [22]. Precarious workers in Sweden were found to be exposed and associated to several adverse health and social outcomes such as self-rated poor general and mental health [102], mental disorders and suicide attempts [103], psychosocial hazards [104], social precarity [105] and increased risk of myocardial infarction and stroke among middle-aged male workers [106]. Alongside these projects, this thesis laid the groundwork by defining and measuring PE by solely using register data to construct a multidimensional operationalization of this phenomenon, and consequently estimated under-reporting of OIs in the precarious population and analyzed the association between PE and OIs.

6.1.1 Defining and operationalizing precarious employment

The systematic review (Study I) identified three overarching dimensions of PE, employment insecurity, income inadequacy, and lack of rights and protection, each characterized by several items. A key finding of the review was that despite differences in definitions and measurements across the literature, and different social and political contexts, a common definition of PE is likely attainable. However, most of the included studies did not define PE *a priori*, and data-driven definitions were predominantly used. Furthermore, most studies operationalized PE through contract status as a unidimensional indicator [107-116]. This thesis argues that considering level of income (income inadequacy dimension) and access to working rights and protection (lack of right and protection dimension) alongside the employment relationship allows for a much broader picture of who could be precarious in the labor market. Furthermore, a multidimensional approach acknowledges that precarity can be a characteristic of both those in a poor employment relationship and workers in standard employment.

Based on the findings of Study I, the first version of the SWE-ROPE was successfully developed in Study II as both a summative scale approach and a typological approach using Swedish register data. When performing the summative scale, a higher level of precariousness (corresponding to low scores) was seen among women, younger adults, individuals with low educational levels, and foreign-born.

A higher level of precariousness was also seen in the private ownership sector and across some economic sectors, such as accommodation and hospitality, agriculture, and arts and entertainment. As to the typological approach, three types of PE were identified: the PE type, solo self-employed, and multiple jobholders. These groups were characterized by unstable contracts, agency employment, poor income, and poor levels of CBA. The findings of the typological approach were largely confirmed by the characteristics identified by precarious levels obtained using the PE score. When the PE score was further implemented in Study III and IV to investigate the under-reporting of OIs and PE as a risk factor for OIs, the characteristics of the precarious population were once again confirmed according to expectation. A register-based assessment of PE provides excellent opportunities to develop new study designs and methodologies that can be used to advance the research on PE and its adverse effects on health. It allows for the monitoring and surveillance of the precarious working population and their risk of poor mental and physical health.

6.1.2 Precarious employment, under-reporting levels, and risks of OIs

Study III is the first register-based study showing that under-reporting levels were consistently higher among precarious workers in Sweden in 2013. The under-reporting levels of OIs were higher among precarious workers than non-precarious workers, across all sociodemographic characteristics, occupations, ownership sector, and when accounting for injury severity. When looking specifically at under-reporting across PE dimensions, workers with unstable employment and multiple job holders with more than three employers and workers with the highest and lower level of income were found to under-report the most. While most of these novel findings were in line with our expectations and hypothesis, high levels of under-reporting among workers earning the least and those earning the most were unexpected. We interpreted this apparently similar phenomenon as driven by different reasons.

It could be suggested that highly educated and high-income workers could be employed in jobs where the OI does not impact workability. On the other hand, low-educated and low-income workers may consciously decide not to report an injury to avoid losing one's job [78-80, 117]. Therefore, understanding accurate estimates of OIs allows for the creation of preventive measures targeting specific occupations or sectors prone to higher under-reporting levels. It can also contribute to improving the reporting systems in organizations that present a high level of under-reporting. Moreover, specific health and safety programs could be designed to tackle the most vulnerable groups in the labor market, such as precarious workers.

Finally, Study IV explored PE as a risk factor for OIs among precarious and non-precarious workers in Sweden between 2006 and 2014. In this study, our hypothesis of precarious workers being at higher risk of OIs than non-precarious workers did not sustain. Using the PE score as an exposure, precarious workers were found to be at lower risk OIs when accounting for under-reporting levels and time-at-risk. Nevertheless, in the item-by-item analysis of PE (contract insecurity, contractual temporariness, multiple jobs/sectors, income level, CBA), workers employed by an agency, individuals having three jobs in more than one economic sector, and women with lower salaries were at higher risk of OIs. When looking at the "unstable employment" item, we did not find that workers in unstable employment had a higher risk of OIs than those in stable employment. A factor influencing this finding could be the heterogeneous nature of this group of workers since the definition of unstable employment had an employer for less than 3 years. Even though the findings from the PE score did not confirm our hypothesis, the increased risk of some of the item-by-item analyses met most of our expectations. Further research should investigate how working in multiple workplaces affects temporary agency workers and multiple job-holders risks of OIs and understand how and if precarious workers gain occupational tenure despite their employment instability.

6.2 Methodological considerations

6.2.1 Study design

This thesis included different study designs: a systematic review (study I), cross-sectional studies (study II, III), and a longitudinal study (study IV).

While a strength of Study I was to conduct the systematic review across several scientific disciplines, an issue to consider regarding study design is that there is little guidance on integrating different types of studies, methodologies, and data within the same review.

To strengthen the study design and reduce evidence selection bias (when a review does not include all available data) and reporting bias (deviation from a protocol), PRISMA guidelines were followed to the closest possible extent, and a research protocol was developed prior to conducting the study.

When it comes to cross-sectional and longitudinal studies, essential aspects that need to be considered to minimize biases (e.g., misclassification, reverse causation) are choosing a representative sample, having a sufficient sample size, defining specific inclusion and exclusion criteria, as well as controlling for possible confounding factors [118]. Thanks to the practically complete coverage of the Swedish working population and the implementation of thorough exclusion/inclusion criteria for all studies, those aspects were met in the studies. While cross-sectional studies provide a snapshot of the relationship between exposure and outcome, longitudinal studies investigating exposure and outcome overtime may be hampered by reverse causality, e.g., OIs leading to PE conditions. To account for reverse causation, in study IV, the exposure was measured the year prior to the outcome, e.g., PE measured in 2006 and OIs in 2007, as well as by adjusting for any prior workplace injury that the individual may have had the year before the measurement of the exposure. Last, a proxy variable to account for part-time working was used to account for time at risk.

6.2.2 Exposure assessment

The high-quality and coverage information provided by the Swedish registries allowed a detailed and objective measurement of both PE in this thesis. This facilitated a cross-sectional and longitudinal investigation of both exposure and outcome. The register-based data allowed for the inclusion of a range of important factors, e.g., socio-demographic characteristics, occupations, sector ownership, and economic sectors related to PE and OI that many existing studies have not taken into account.

The assessment of PE in the registries was the first step towards operationalizing an objective multidimensional construct and was based on a solid theoretical and empirical approach derived from the analysis conducted in Study I. Thereafter, a thorough investigation of the available data present in LISA was conducted, and the most appropriate variables were used to operationalize the SWE-ROPE as employment typologies and as a summative score. In this sense, the typological approach does not provide us with employment types that can easily be ranked as the summative scale approach.

Nevertheless, to identify degrees of precariousness using the summative method, there is the need for a cut-off score representing PE to be set. Across the studies, the 25th percentile of the summative score for the total population was used to identify precarious workers. In Study III, the cut-off for the precarious group was set at -3, which corresponded to the limit of the first quartile of the population, while study IV was set at -4. The decision affected only the share of precarious workers marginally, which resulted in approximately 2% of the precarious population moving into the “middle group”. Such decision was driven by the willingness to be more conservative in terms of the population estimated to be in PE, thus decreasing the miss-classification of workers who may not be in PE.

Moreover, the scoring method facilitated estimating under-reporting OIs in 2013 and investigating PE as a risk factor for OIs between 2006 and 2014 since categories do not change over time, whereas the number and interpretation of employment types could change from year to year. Finally, on top of providing results for precarious and non-precarious workers, in both study III and IV we decided to present under-reporting levels and calculate OIs risks for each item of PE, to give an in-depth perspective of which dimensions may pose greater risks for workers' health and thus facilitate the design of targeted intervention.

6.2.3 Random and systematic errors

6.2.3.1 Random errors

Random error is a measurement error that arises by random variation in a study and thus is independent of any study design. The impact of random error imprecision can be minimized with large sample sizes [119]. Thus, the rich data availability provided by the registers in Study II, III, and IV, allowed the inclusion of a sufficiently big sample size that minimized random error in such studies.

6.2.3.2 Systematic errors

Several sources of systematic bias exist, which can lead to an incorrect estimate of the association between exposure and outcome (underestimation or overestimation) [119]. Such bias can be introduced in different research study phases and can affect study validity (internal and external). Selection, information, and confounding are three main categories of bias.

Selection bias can occur during the selection of study participants or by factors that could affect study participation [119]. Using the national registries allowed for selecting the total working population in Sweden. Since the registries cover only individuals officially residing and registered in Sweden, specific categories of workers may be excluded from the studies, such as informal workers posted workers employed in companies registered in other countries. Potential sampling issues could also affect recent immigrants who are not yet registered in the system and thus would be excluded from our studies, and the generalizability of our results may thus not extend to this population. These groups represent a small size of the overall working population in Sweden [120], and thus the potential under-estimation is considered minimal. Nevertheless, excluding these groups of workers may result in underestimating our exposure since these are likely to be precarious, and underestimating the outcome may lead to increased levels of under-reporting.

Information bias is defined as a lack of accurate measurements or classification of information on study participants [121]. Such misclassification can occur both for the exposure and outcome in a study if they are incorrectly classified and can bias associations towards the null. For example, across all register studies in the thesis, misclassification of the exposure could have occurred when deciding the cut-off for precarious workers in the summative scale approach.

This may have misclassified some workers in study III into precarious since the cut-off for PE was -3, compared to a cut-off of -4 in study IV. Furthermore, the misclassification in the exposure could have occurred in earlier stages of creating the summative score, where we assigned negative or positive values to specific categories of workers, which not necessarily may be precarious, e.g., multiple jobholders, self-employed. Nevertheless, operationalizing PE as a multidimensional construct helps minimize this misclassification by assessing the worker's precarious level based on ranking negative values on several items, e.g., being a multiple job holder in multiple sectors, having low income, and not being covered by CBA. As to misclassification of the outcome, all registers used to extract data on the injuries (ISA and AFA) have close to total coverage of all reported workplace injuries, and thus misclassification is unlikely. However, since OIs in ISA and AFA are self-reported, recall bias may occur when the individual reports how many days of sickness absence were caused by the workplace injury, resulting in misclassification of injury severity. Moreover, in Study III, injuries in ISA and AFA were linked based on a ± 7 days range, with injuries reported within a week in either of them considered the same workplace injury. This may increase misclassification of the outcome, particularly among less severe injuries which are not necessarily reported on the same day they happened. Finally, human error may also occur when registering the date or information of OIs into the systems and thus contribute to misclassification of the outcome.

Last, confounding can be defined as the distortion of the associations between an exposure and an outcome caused by a third variable [119]. To account for confounding, study III and IV results were adjusted for potential confounders of the association between PE, under-reporting, and OIs. These confounders were selected based on a careful inspection by means of DAGs in order to include only the minimal sufficient adjustment consideration. In both studies, both crude and adjusted models were run and compared.

6.2.4 Generalizability

The dimensions and items of PE identified in Study I were the result of a systematic review that included studies from multiple countries. Thus, while PE remains a concept shaped by country-specific labor markets, legislations, social systems, economics, etc., the dimensions can be operationalized with country-specific data beyond Sweden's borders. On the other hand, the SWE-ROPE constructed in Study II is an operationalization that was achieved thanks to the rich data availability provided by the registries. Other countries having unique identifiers linking multiple registries, such as neighboring Nordic countries, may be able to operationalize the dimensions using their specific registries and perhaps operationalize items of PE which were not measured in the SWE-ROPE.

The findings in Study III and IV can be considered generalizable to the whole working population in Sweden. The nearly total coverage of the registries and all occupations and economic sectors included in the studies favored such generalizability. Specifically, the under-reporting levels of OIs found in the injured working population in Sweden can be considered generalizable to the source population and further to working populations in countries under similar working conditions and welfare systems. Similarly, the increased risks of OIs found in a specific group of workers can be generalizable to neighboring countries and to a certain extent to western societies that have witnessed an increase in NSWA and PE. Nevertheless, our findings may not apply to self-employed since this category of workers was excluded from Study III and IV.

6.3 Future directions

To date, research, practice, and policies based the quantification of workplace hazards on the SER. However, today's segmented labor market structure has implications for workers' health and safety by potentially intensifying existing hazards or creating new ones which may affect disproportionately those in PE. Therefore, conventional approaches to research, interventions, and policies may not be any longer adequate. SWE-ROPE was created based on an analysis of the literature and thorough exploration of the registries to define the current precarious population in Sweden and consequently investigate possible associations to OIs. Nevertheless, the changing nature of PE requires a continuously adaptable construct to account for present and future features that were not included in the SWE-ROPE.

First, to account for all items of the dimensions, the rich information provided by the registries could be paired with other methodologies, surveys, or interview-based studies. This would allow filling current shortcomings, such as involuntary part-time employment, contractual renewal unpredictability, income volatility if multiple job-holders have multiple jobs simultaneously or scattered throughout the year. In addition, since one of the major features of PE is employment instability, it is recommendable to collect specific information as to the length of employment and if the individual is working in the same job task. These would clarify “occupational tenure” in the precarious population across occupations and economic sectors, and consequently, their effects on health and OIs.

Second, the summative score was used to investigate the relationship between PE and OIs in Sweden. While the score allowed an optimal categorization of the population into precarious and non-precarious workers, it did not allow discerning in the same way the working population lying in the middle (defined as borderline precarious in Study III and middle group in Study IV) and most likely representing individuals in NSW. Thus, the typological approach may better investigate this heterogeneous group of workers. Furthermore, other study designs are encouraged to investigate the association between PE and OIs longitudinally. While the repeated prospective study allowed a first exploration of the direction of this association, we did not explore how changes over time in the precarious level of an individual may be associated with a greater risk of OIs. We further did not look if precarious workers are at increased risk of suffering multiple work-place injuries.

Furthermore, specific socio-demographic characteristics were associated with PE, such as women, young adults, and foreign-born workers. Further research should investigate possible mechanisms through which PE leads to adverse mental and physical health outcomes in these specific working populations and if they have increased risks of finding themselves stuck into PE. Finally, longstanding precarious attachment to the labor market and possible effects on OIs and health overall must move from cross-sectional to longitudinal designs to account for changes over time in both exposure and outcome.

7 CONCLUSIONS

This thesis contributed to the advancement and development of PE as an occupational exposure and its relationship with under-reporting and OIs in Sweden. Study I confirmed that despite the literature's heterogeneity in definitions and operationalization, a common understating of PE is both feasible and attainable. The three final dimensions -employment insecurity, income inadequacy, lack of rights, and protection- were subsequently operationalized into the SWE-ROPE in Study II following a typological and summative scale approach. The latter approach was used in Study III and IV to investigate the relationship between degrees of PE and under-reporting and risks of OIs. Under-reporting levels of OIs were higher among precarious workers than non-precarious workers across all socio-demographic characteristics, also when accounting for occupation and injury severity. On the other hand, precarious workers were found in Study IV at lower risk of OIs than non-precarious workers, even when considering under-reporting levels, injury severity, and occupations. Nevertheless, workers employed by an agency, individuals having three jobs in more than one economic sector, and women with lower salaries were at higher risk of OIs.

The lack of conceptual clarity and the complexity of defining and measuring PE challenges the interpretation of the existing evidence concerning OIs. To contribute to the research and policy advancement, this thesis highlighted that tracking the precarious working population in the labor market, accounting for under-reporting levels, and looking at risks of OIs is feasible. These facilitate the surveillance of the precarity level of the labor market and OIs in Sweden. It also allows addressing any health, societal and economic need that precarious workers may present. The current social security system does not meet such needs, with the precarious working population often not eligible for social benefits for which a person qualifies through their employment. Monitoring how PE and OIs develop over the life course allows developing programs and policies to increase workers' protection in the labor market and develop targeted health and safety programs to address root causes of OIs. Thus, longitudinal studies are needed and are encouraged to validate these measurements and operationalizations and to increase international understanding and comparability of these phenomena.

8 ACKNOWLEDGMENTS

Where to even begin. Each of you has made this Ph.D. the best ride someone could have on what has been a roller-coaster of emotions. So, for once, I want to take the time to thank all of you.

Theo, you are the most unique, inspiring, and fun main supervisor/friend someone could wish for. No matter where we were, you have always been there, whether listening or motivating me, checking or guiding me out of frustrating loops. Thank you for ensuring that this journey was the rich experience that it has been all along for me, for letting me wonder about new ideas, and at the same time, remember me to keep a foot on the ground. For the continuous effort you put into finding new ways of improving research and ourselves as researchers. Grazie! My dear co-supervisors **Tomas**, **Carin H.** and **Cecilia**. No matter how busy you all might have been, no matter how a worldwide pandemic affected us, you were always there when I needed support, whether in-person or online meetings. Thank you for your constant support.

Göran, my mentor, thanks for always finding the time to have nice discussions on global health and health policy, making me reflect on the broader picture. I have truly appreciated your support and guidance during these past years.

A special thanks to all the task force of co-authors in the CURSOR/KIROS project and PWR. Thank you all for the constant active participation and for sharing with me all your knowledge and expertise along with this Ph.D. A special thanks to **David** and **Letitia** for such an invaluable presence even from overseas. You have contributed so much to this journey from both a personal and professional point of view. I have enjoyed working with you and learned so much from you. Your passion for the “cause” and love for transmitting knowledge is truly inspiring. Thank you.

Thank you, **Johanna** and **Nuria**, for being the best precarious dream-team and friends I could ever wish for by my side. Johanna, you have always been there for me with your sweetness and kindness, ready to jump on a fun chit-chat (or cold sauna), or on hours of challenging brainstorming. Nuria, the degree of laughing we can have is truly a blessing. You are my other half from Spain, and I cannot even describe how complementary our personalities are and how this has made work and life so much fun.

My gratitude and love **extend to all my colleagues and friends** in my research group at the Occupational Unit, CAMM, and IMM. Thank you for the fantastic spring parties, unit days, and fikas that I was lucky enough to share with you. Dear **Torsplan colleagues**, Kathryn, Emma C., Karin G., Xuelong, Signild, Melody, Julio, Claudia, Liyun, Katrina, Helena, Karin N., Gun, Calle, Jouni, André, and all other colleagues, I am indebted to all of you for how special you have made this journey. I will always cherish the many fun lunches and breaks where we could genuinely end up talking about the most extravagant topics, run to a bakery for a healthy intake of sugar or improvise after works. **Emma C.** and **Kathryn**, you have made special our office-life by sharing all the perks of our daily Ph.D. existence, thank you. Kathy, I will leave the blaming of the many pastries and drinks we have had to another time. This time I want to thank you for such a special friend you have become to me; the warmth that you and your beautiful family have given me, is priceless. Thank you to also **Karin N.** and **Helena** for the fun, jokes, sarcasm, nice after works alongside all the talks and support that I always received from you. Our friendship has been a blast from the real beginning. Thank you, **Maria A.**, you are a source of great inspiration, and thank you for your unique capability to always listen and support young researchers and for having contributed, along with other directors of KI/CAMM to a truly special work environment.

Thank you, my special and dear friends in Stockholm and everywhere else in the world. Whether by calling me, texting me, visiting me, traveling together, you have always been there with me and for me. Thank you. **Niina**, only a pandemic could temporarily stop us from seeing each other, but since the days in Lund you are one of my pillars and always will be. **Philipp**, thank all the existing gods or universe forces for the day we moved in when I relocated to Stockholm. These four years would have never been the same without you, without all the binge-watching, binge-drinking, lunches, dinners, getting lost in philosophical thoughts (and in general) as well as just laughing out of nothing. You are truly a special friend. Thank you.

My **beloved family**. There are no words whatsoever that I can use to thank you for just being the most special, supportive, fun and strong family someone could ever have. Mum and dad, the biggest gift you could ever give me is just being your daughter. You have shown me how everything is better by just being together and you have taught me how the strength of a laugh can literally turn the darkest day into the brightest. Thank you. Fabio and Arsela, you are the best siblings someone could ever wish for. Thanks for just being always by my side. My beloved in-laws, Paola, Erich and Thai. From day 1 you have been there for me, with all your sweet and genuine love and support. What a lucky person am I?

Last but not least, **Artú**. Thank you for just existing. Nothing can be compared to the 9 years together, and the many to come. Our life together is the biggest achievement I could wish for. I love you.

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