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# Precarious employment, business performance and occupational injuries – a study protocol of a register-based Swedish project.

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**ABSTRACT**

**Introduction:** There is uncertainty regarding the trends in occupational injuries (OI) in Sweden due to a significant and increasing problem with under-reporting to injury registers. Under-reporting in general is likely to be exacerbated by the rise in precarious employment (PE), a set of unfavourable employment characteristics that would benefit from formal definition and study. PE and global trends is believed also to affect companies and their commitment to health and safety. The present study attempts to bridge these knowledge gaps and presents a study protocol for planned studies, with three main objectives: first, to review the literature for definitions of PE emphasizing those that are multi-dimensional and operationalize components in routinely collected register data; second, using results from the first objective, to conduct large, register-based prospective studies, designed to measure effect sizes and interactions between PE, business performance and OI; and third, to estimate the under-reporting of OI in Swedish registers.

**Methods and analysis:** First, a scientific literature review will be conducted, including scientific databases and grey literature. Second, all residents aged 18-70 in Sweden with any registered income during 2003-2015 will be included. Data sources encompass Swedish population and labour market registers with linkage to both the main occupational injury register with national coverage and hospital records. Trends in PE and OI will be explored, together with risk of OI associated to PE and business performance. Finally, data from two major occupational injury registers will be used to estimate the magnitude of under-report using capture-recapture methodology.

**Ethics and dissemination:** The project has been approved by the Regional Ethics Committee, Stockholm (dnr:2016/2325-31;2017/2173-32). Dissemination of study results will include a series of peer-reviewed papers, a PhD thesis and one report in Swedish, engaging relevant stakeholders. Results will be presented in national and international conferences and through press releases to mass media.

**Keywords:** Precarious employment, occupational injury, business performance, study protocol, register-based.

**Article Summary**

**Strengths and limitations of this study**

- We present a systematic approach to operationalization of the arising social determinant of health; precarious employment. This effort is much needed and is likely to be valuable to the research community.
- The use of nation-wide register data of high quality covering the total working population provides power to the study and virtually zero-loss to follow-up.
- A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias.
- Potential risk of misclassification for both exposure and outcome, due to factors such as data availability and self-reporting.
- For the under-report of occupational injuries, the main limitation refers to differences in the coverage of the different data sources, which will limit our ability to make good estimates in some labour market sectors.

**INTRODUCTION**

Setting priorities for workplace health and safety research depends upon accurate and reliable accident and injury data. In Norway and Denmark studies suggest that as few as 9-26% of all occupational accidents reaching hospitals are also reported to the national occupational injury registers. [1, 2] There is uncertainty regarding the trends in occupational injuries in Sweden due to under-reporting to Swedish injury registers. [3, 4] It is known that larger workplaces in Sweden generally have better routines for reporting occupational injuries than smaller companies. [4] Among the latter, there is a widespread poor awareness that reporting of occupational injuries is mandatory. No systematic analysis of the magnitude of under-reporting and factors associated with this problem has been performed.

The problem with underreporting could be exacerbated by the rise in precarious employment, non-standard employment relations encompassing short-term and temporary contracts, as well as powerlessness, vulnerability, employment insecurity and insufficient wages. There is no internationally accepted definition of precarious employment, but several multidimensional constructs have been proposed. [5-7]

There is reason to believe that precariously employed workers are less likely to report occupational injuries due to lack of knowledge, education, unionization and empowerment in exercising rights. Precariously employed workers are also likely to be at higher risk of occupational injuries. A recent review by our group [8] supports an association between some of the dimensions of precarious employment and occupational injuries; most notably for multiple jobholders [9-12] and employees of temporary agencies or subcontractors at the same worksite. [13-15] Results for employees on fixed-term contracts were inconclusive.

The rise in non-standard employment relations is a trend in many countries in all stages of development and Sweden is no exception. Here, temporary employment rose during the nineties crisis and is especially common among young adults, where the proportion on temporary contracts

is 65% among both men and women aged 20-34. [16] International trends in management and increased competition also affect companies and their commitment to health and safety. In order to stay economically competitive and to earn maximum profits, it has been found that construction contractors only execute basic safety measures and eliminate many important hazard prevention training programs during project implementation. [17] Others have found that when the financial condition of a firm deteriorates, then it is likely to adopt policies that will lead to an increase in safety violations, an increased accident rate, and an increase in environmental hazards. [18] In contrast, companies that prosper could be more likely to invest in occupational health and safety. In a study of U.S. coal mining companies a 10% increase in real total revenue per hour worked was associated with 0.9% decrease in the incidence rates of all reported injuries. [19] However, which variables are good indicators of business performance and what is the situation in Sweden has not been explored.

Research regarding the association between precarious employment, business performance and occupational injuries faces several challenges. Firstly, the employer-employee relationship is increasingly complex and there is mounting evidence that a single variable, such as temporary employment or job insecurity is not enough to explore this relationships association to health outcomes. [8, 20, 21] A multidimensional approach is needed, but the variety in definitions used makes comparison between studies and countries difficult.

To address these challenges, ***the first objective*** of this project is to review the literature for multi-dimensional definitions of precarious employment and similar constructs and identify its main components. We will then suggest ways to operationalize these components in routinely collected register data.

***The second objective*** of this project is to use the results from our methodological work in the first objective to conduct large, register-based prospective studies, designed to identify trends on the labor market and measure effect sizes and interactions of the relation between precarious

employment, key business indicators and occupational injuries as well as their interaction with sociodemographic and economic indicators.

Finally, there is a pressing need for better injury statistics in order to set priorities for prevention and future research. Therefore, ***the third objective*** of this study is to estimate the magnitude of under-reporting of injuries in Swedish registers and investigate which factors are related to this.

In this protocol we provide an overview of the data sources and methods to be used in the project.

**Specific Research Questions**

Studies are planned based on specific research questions (RQ) aligned to overarching objectives above.

Objective 1

RQ1. How has precarious employment been previously defined and how can this be operationalized in Swedish registers?

Objective 2

RQ2. What are the trends in precarious employment on the Swedish labour market?

RQ3. What are the occupational injury trends over time for precarious workers and organizations or industries that go through economic change?

RQ4. Are precarious workers at higher risk of occupational injuries compared to others?

RQ5. Are changes in key business indicators risk factors for occupational accidents over short-term and long-term periods?

Objective 3

RQ6. What is the magnitude of under-reporting of occupational injuries in Sweden 2013, and is underreporting differential with respect to:

a. individual factors such as age, sex educational level and precarious employment status,

b. organization-level factors such as company size, industry or sector, gender composition, age composition, and proportion of immigrant workers,
c. injury severity, and cause of accident?

**Ethics**

The project has been approved by the Regional Ethics Committee, Stockholm (dnr: 2016/2325-31 and 2017/2173-32).

**METHODS AND ANALYSIS**

**Description of data sources**

This study includes all residents aged 18-70 in Sweden with any registered income during at least one year, January 1st 2003 through December 31st 2015. For the main analysis this cumulatively amounts to approximately 7 000 000 individuals over the years 2003-2015.This project will use the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA) with linkage to the Information System on Occupational Injuries (ISA) and hospital records, described in greater detail in Tables 1 and 2. We will use the unique personal identity number assigned to each resident in Sweden to link information from all the registers mentioned above. Also, there is an identification number specific for each company and workplace within companies, which will allow us to make an additional company-specific linkage. This linkage will provide aggregate exposure data at the company level, such as company-specific characteristics related to individuals, number of employees at each workplace, etc. We will also be able to follow individuals moving between workplaces.

Statistics Sweden has de-identified the original identification numbers, thus ensuring the confidentiality of the information.

**Table 1.** Characteristics of the data sources used in this project to identify occupational injuries.

| Data Source | Population Covered | Injury reporting and definition | Eligibility, compensation and data access |
|---|---|---|---|
| ISA[a] (Information System on Occupational Injuries) | All employees and self-employed persons in Sweden.<br>To be employed in Sweden you need to be a resident (temporary or permanent) or EU citizen. EU-citizens can work without registering to the authorities for up to 6 months. Those directly employed in EU/ESS or third country but stationed in Sweden are not covered. | The employee is responsible to notify the employer who in turn is obliged by law to report any injury. There is no deadline for reporting an injury. Reports are filed online and to a lesser extent on paper.<br>An occupational injury is 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.<br>Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents." | Days of work lost due to the injury (except in the case of annuity) are paid through the regular sickness benefit system*. So, despite the law to report injuries, no report is needed to get compensation lost work days.<br>The worker can claim compensation for costs related to dental care, special assistive devices or medical care abroad.<br>If the injury is likely to reduce work-ability for more than 1-year, compensation for lost work income (annuity) can be approved if the injury has led to a lower income for the worker (other job and/or fewer hours).<br>The injury reporting system (ISA) automatically sends the report to the national insurance board who administrates both the sickness benefit and worker's compensation but no assessment of the injuries validity is made unless the worker makes a claim for compensation.<br>Data access: Open and closed cases are available alike at the time of data extraction. Final statistics are published approximately 11 months after the close of the calendar year.<br>* except for special cases where the worker doesn't qualify for sickness benefit or if his/her sickness benefit is low. These workers are covered by the |

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| | | | occupational injury sickness benefit. |
| AFA insurance[b] | All employees within the private sector (also self-employed) who have signed a collective agreement. All employees in municipalities and county councils as they are always covered by collective agreements. AFA also administrates the occupational injury insurance for all national government employees. Thus, in total, the AFA register covers 100% of the public sector employees and approximately 90% of the total Swedish Labour market. The same regulations regarding employment in Sweden as described under ISA applies. | Employees report directly through an online form to AFA. There is no deadline for reporting an injury. However, there is a 10-year deadline to receive compensation (6 years for income loss) The same definition of occupational injury is used as for ISA. | Eligibility: The employer confirms that the person was an employee at the time of the injury through a direct query from AFA. AFA also checks with the national insurance board if there are sick-days reported. The claim's validity is assessed and if granted compensation can be given for lost income, direct costs associated to the injury and sometimes compensation for pain and suffering. If the injury still causes suffering after 18 months, compensation can be given for medical disability/permanent impairment and/or annuity. Thus, AFA provides a broader compensation scheme than the national insurance board.<br><br>Data access: Open and closed cases are available alike at the time of data extraction. |
| [a] ISA register is held by the Swedish Work Environment Agency<br>[b] AFA is a privately held insurance company owned by the Swedish trade unions and employer's organizations. Available data for the year 2013. | | | |

Apart from the data sources described above, for the third objective we will also include occupational injuries that occurred in the year 2013 using data from AFA Insurance, an organization owned by the Sweden's labour market parties (Table 1).

**Table 2.** Additional sources of data used in this project.

| Data Source | Population covered | Available variables | Timeliness |
|---|---|---|---|
| LISA (Longitudinal Integration database for health insurance and labour market studies) [a] | It holds annual registers since 1990 and includes all individuals 16 years of age and older that were registered in Sweden as of December 31 for each year. | The database integrates multiple databases from the labour market, educational and social sectors. It contains not only individual data, but also connections to family, companies and places of employment. | Temporal resolution: Variables are on yearly basis for both individuals and businesses, this applies to e.g. income, revenue, etc.<br><br>Multiple employers are registered (total number and details on the three major employers).<br><br>Data access: Data is compiled with an 18 months' lag. |
| NPR (National Patient Register) [b] | All visits to inpatient or specialised outpatient care (i.e. excluding primary care). | Our dataset includes every person who was diagnosed with external cause of injury (ICD10 chapters S and T). Duration of hospitalization, to characterize severity. | All hospitals and specialized outpatient clinics in Sweden report to a central register, coverage is >95%.<br><br>Data includes exact date of visits admission and discharge. |
| DR (Cause of Death Register) [b] | It includes all those who died during one calendar year and were registered in Sweden at the time of death, regardless of whether the death occurred inside or outside the country.[c] | It shows the underlying cause of death coded according to the international version of the disease classification ICD-10. For injuries, the external cause of injury is shown. | Reported by physician no later than 3 weeks after death. |

[a] LISA is held by Statistics Sweden. [b] NPR and DR are held by the National Board of Health and Welfare.
[c] The statistics do not include stillborns, persons who died on a temporary visit to Sweden or asylum seekers who have not yet obtained residence permits. Swedes who have emigrated and are no longer registered in Sweden are not included either.

**Main variables**

Precarious Employment and Key Business Indicators:

The definition of precarious employment will be developed through the systematic literature review, development of a functional PE definition applicable to available registers and then operationalization in registers (RQ1). Information on exposure to precarious employment and key business indicators will be constructed from data obtained through LISA register (Table 2).

Relevant key business indicators will be selected though discussions and workshops within the research team, that includes a business economist. There is very limited guidance in previous research on which key business indicators could be related to occupational injuries. Under the well-founded assumption that managers make decisions (including those affecting health and safety) based on the projected future of the company, the initial work has focused on identifying key indicators of company value, as reflected by operating assets, future earnings and cash flows. Preliminary discussions suggest that return on equity, operating margin, net turnover/employee, employee costs/net turnover, solidity, operating result/employee, employee costs/employee, financial leverage, labour costs as well as total gross and net investments are highly relevant. All these variables are available directly from LISA for all Swedish companies. Stock market prices have been contemplated but discarded since most companies are not listed. We also have ongoing work identifying which key business indicators that are useful in comparing companies across industries and within specific industries. Likely we will adopt an exploratory approach on a subset of the dataset before deciding on which indicators to use.

Occupational Injuries:

Information on occupational injuries caused by an accident is being obtained from two different Swedish registers: ISA and AFA Insurance (Table 1). Thanks to the linkage with Swedish population and labour market registers together with hospital records, we will be able to characterize injuries in terms of severity and add information on potential confounders.

Occupational Injury Definition:

We will use the definition used in Swedish Law and which is applied by both the ISA and AFA registers. *"An occupational injury is 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.*

*Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents." [22]*

Since under-reporting is one of our main objectives, we will study reported occupational injuries. In ISA, claims can only be made for a limited set of compensations (Table 1). No assessment of reports is made without a claim; thus an inclusion of claims or approved claims would be too limiting. The occurrence of false reports is thought to be very low (personal communication with the work environment authority) and is likely random. However, we will explore this issue further.

Moreover, we will exclude injuries that occurred during transit to/from work, occupational diseases and near injuries.

*Occupational Injury severity*

Severity of occupational injuries will be assessed in two different ways.

Days of work lost: Data from the Swedish Social Insurance Agency provided by employers and part of the ISA and AFA registers, will be used to obtain days lost from work due to sickness absence and disability pension, in connection with occupational injuries. This information covers all employees.

Specialized care, Hospitalisation and Death: Specialized care, Hospitalization and Death will be obtained from the National Patient Register (NPR) and Cause of death register (DR) (Table 2). We have limited this study to chapters S and T in International Classification of Disease 10 (ICD-10) which contain injuries, poisoning and some other consequences of external causes. Since all diagnoses are not covered, this dataset does not include all occupational injuries leading to specialized care, hospitalization and death. Regarding injuries to the musculoskeletal system, it only covers fractures, dislocations and distortions. However, it will allow a subpopulation analysis of severe acute injuries in RQ2-6.

**Covariates/Confounders**

We will use information from LISA register to adjust for confounding factors, perform stratified analysis and sub-group analysis (Table 2).

Individual: age, sex, educational level, income, country of birth (four groups: Sweden, other Nordic country, other EU 25, and rest of the world) and occupation according to the Swedish Standard Classification of Occupations (SSYK 1996), [23] which is based on the International Standard Classification of Occupations 1988 (ISCO-88).

Workplace: In addition to key business indicators, we have information on workplace level on industry (Swedish Standard Industrial Classification), [24] number of employees, educational level of workforce and workplace sex distribution.

**Analysis plan**

Definitions and operationalization of precarious employment (RQ1)

We will deconstruct all definitions obtained by our literature search into single dimensions and perform a qualitative and quantitative appraisal of their appropriateness. Based on our findings, we will propose a core set of variables that should be included in a multidimensional definition of precarious employment depending on data availability. Once these are defined, we will operationalize a multidimensional definition in Swedish registers to be able to use it in the subsequent studies and develop a job exposure matrix for precarious employment including these variables (study 1).

Trends in precarious employment and occupational injuries (RQ2 and RQ3)

Using data from the whole study period, we will then explore trends in precarious employment over time in Sweden, for the years 2003-2015 (as laid out in study 1). We will put special attention to changes over time for women and men, different industries, and foreign born compared to Swedish born (study 2).

We will also explore the trends over time with regards to the risk for occupational injuries for precarious workers and organizations or industries in economic trouble (study 3).

Risk of injury associated to precarious employment (RQ4)

Precarious employment, as defined though formative work in study 1, will be the independent variable of interest in a multivariate analysis with occupational injury as outcome. It is well known that the risk of occupational injuries decreases with tenure at any given job. It is unlikely that there is an accumulation of risk or latency in the precarious employment–occupational injuries relationship. We will therefore measure risk and outcome at the same point in time, i.e. precarious employment and injury in the same year. We will also explore the interaction effects of age and tenure/experience. Analysis will be adjusted for socio-demographic variables. A longitudinal dimension will be introduced by analyzing the changes in risks over the time of the study period (2003-2015). Due to the large differences in risk of injury based on occupation, sector and industry, we will perform stratified analysis based on these variables.

The outcome will be stratified based on severity of injury and differences in risk of injury severity between precarious and non-precarious employees will be explored.

Risk of injury associated to key business indicators (RQ5)

A cohort of all Swedish companies will be created. The outcome will be defined as occupational injury per full-time employee and calculated for each year for each individual company. We will calculate short-term (1 year) and long-term (5-year) trajectories in key business indicators for each company and use these as the main independent variables of interest in a multivariate regression analysis. Stratified analysis will be carried out based on company size, industry/sector. As in RQ4, the outcome will be stratified based on severity of injury.

Under-reporting of occupational injuries (RQ6)

In order to estimate the magnitude of underreporting of occupational injuries for the year 2013 (RQ6), two sources of data on occupational injures (ISA and AFA registers) will be used to obtain

estimates by means of capture-recapture methodology (study 6). This method, based on log-linear models, has been successfully used by others and it is used to estimate the incomplete ascertainment using information from overlapping lists of cases from distinct sources. [25]

**DISCUSSION**

In this project we aim at operationalizing precarious employment in Swedish labor market registers and use this definition to conduct several large, register-based prospective etiological studies, designed to measure effect sizes and interactions of the relation between precarious employment, business performance and occupational injuries. Taking advantage of two separate and comprehensive reporting systems for occupational injuries in Sweden we will also estimate under-reporting of occupational injuries and the factors which are related to this issue. In this protocol, we present preliminary results for the overlapping of occupational injuries for the year 2013.

**Strengths and limitations**

We believe that the major strength of our project will arise from the results from the first study, i.e. the operationalization of precarious employment. This, together with the identification of key business indicators of relevance for the association between precariousness and occupational injuries can be considered as a valuable start point for future research investigating these factors.

By using the unique Swedish personal and organisation identification numbers from ISA and LISA we are able to link both individuals and companies to each other and to the injury databases. The use of nation-wide register data of high quality covering the total working population provides power to the study and virtually zero-loss to follow-up. A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias. Information on sickness absence and hospitalization allows us to characterize our outcome in terms of severity, further adding quality aspects to outcome measurement.

However, some limitations and methodological challenges should be addressed.

Injury definition:

The system of self-reporting and somewhat ambiguous definition of occupational injury introduces the risk of misclassification between occupational injury and disease. This problem is likely to be most serious in the case of musculoskeletal disorders (MSDs) where repeated over-exertion leading to an MSD could be reported as both an occupational injury and occupational disease. For women, over-exertion injuries (physical over-exertion such as during heavy lifting and carrying, jerks, slips) constituted the second most common cause/type of occupational injury with at least one day of sickness absence in Sweden. [26] For men it was the third most common cause. If the misclassification was random and steady over time this would pose a lesser problem, but we have reason to believe that the preference to choose between reporting MSDs as injuries or diseases might be biased by preconceptions about chances of getting a claim granted in either category and that this changes over time as a consequence of regulatory changes.

Additionally, there is risk of including "non-occupational" injuries while investigating reports rather than approved claims. The rationale for not limiting the reports to approved injuries is that the rules for receiving compensation have been tightened over the last decade and we believe that on the group level, there is more consistency over time in employee's notion of what qualifies as an occupational injury than in the assessment by the social insurance agency. In personal communication with civil servants at the Swedish Work Environment Authority, the presence of non-occupational injuries has been deemed "an issue in the margin".

Injury severity:

In Sweden, sickness absence is reimbursed by the Swedish Social Insurance Agency starting on day 15. The near universal coverage of the regular sickness insurance scheme and the additional coverage specifically for injuries makes us rather confident that we will be able to identify most serious injuries occurring in the formal labour market. The other severity measure obtained through

hospital records only covers injuries, poisoning and some other consequences of external causes (S and T chapters in ICD-10). Thereby, we will not identify major injury categories such as acute lumbago (M45.3).

Whether we characterize severity in terms of days of hospitalization or reimbursed days lost of work, we have a rather large difference between mild and severe cases, losing the broad spectrum of less severe injuries while severe cases can be classified much finer.

Precarious employees:

Although we have not yet operationalized precarious employment in registers, we foresee some constraints. Among other issues, type of contract (permanent/temporary) is not registered and will have to be constructed by proxy variables with lower specificity. EU citizens stationed in Sweden and informal workers are not covered in this study, groups that are of special interest in research on precarious employment. This is a major limitation but the constraints in data do not allow us to study these two categories of potentially precarious workers.

Precarious employees are less likely to be covered by collective agreements and therefore the issue will be greatest here. We also hypothesise that they are less likely to report injuries. This will affect both our analysis of under-reporting using capture-recapture, and also the estimates for the association between precarious employment and the risk of occupational injuries.

Key business indicators:

Previous studies have found that as the financial condition of a firm deteriorates, it is likely to adopt policies that will lead to an increase in safety violations, an increased accident rate, and an increase in environmental hazards [18] and that when revenue increases the opposite would occur. [19] The opposite might however be true as well. As revenue falls, the work tempo might shift downwards temporarily and the short-term effects on injuries might be positive. Lay-offs of those with least tenure may also leave a larger proportion of experienced workers which could lead to fewer injuries.

Mirroring this; as revenue increases in a company, new employees come in who are at higher risk. Disentangling these effects and counter effects of changes in key business indicators will be a major challenge and will require important formative work on causal pathways and the construction of logic models prior to analysis. Due to the lack of prior research in this area, an exploratory approach using data-mining or machine learning algorithms will also be applied to discover risk factors and pathways which we cannot foresee at the moment.

Working hours:

When calculating risk of occupational injuries, a measure of working hours is needed as denominator in order to make just comparisons. Lacking data on individual working hours in this project we have to rely on proxy variables to make estimations. Due to collective bargaining the wage structure in Sweden is rather homogenous, especially for blue collar workers and white collar workers with low skills. We are currently exploring the feasibility of using wage in combination with occupational code and industry code as well as the public registers on median salaries in certain occupations (survey-based information) to create a proxy for fulltime employment based on the deviation from the median wage.

Formal/informal work:

As this study partly focuses on precarious employment, we need to spell out that this study is only investigating the formal economy. Not including people working in the Informal sector completely or partly will be one of our major limitations. Especially those who are formally employed but receive part of their salary “under the table” will be at high risk of being misclassified. Also, foreign citizens working in Sweden but whose employer is registered in another country will be absent in this study. We know that these workers are very common in construction and logistics, two industries with high risk of injury.

Under-reporting:

Capture-recapture is a method that has been widely used in epidemiology to estimate unknown size of populations. Methodological issues may appear from dependence among data sources being used to obtain estimates. [25] When it comes to occupational diseases, AFA requires that a report is made first to ISA, therefore one would expect a high level of dependency and that AFA would be completely nested in ISA. For occupational injuries, this is not the case and there is a large proportion of injuries that are only reported to AFA. This said, the detected dependency may result in an overestimation of the true population size, and we must therefore treat our estimations cautiously.

Also, the AFA insurance scheme is not as comprehensive as ISA's. The ISA register covers 100% of the employees and self-employed while the AFA register covers 100% of public sector employees and the of the largest employers. However, collective agreements are less common in small companies and certain industries such as hospitality where 45% of the companies have collective agreements. This will limit our ability to make good estimates in some labour market sectors.

**DISSEMINATION**

The project is presently planned to result in a series of papers published in international peer-reviewed scientific journals, a PhD thesis and a report in Swedish aimed at relevant stakeholders including governmental agencies, policy-makers and social partners (employers and trade unions). Due to the richness of the data obtained and the multiple scientific approaches we anticipate that the project will result also in further publications than those outlined in this protocol. Results of public interest will be formatted as press releases and sent to Swedish and international media with support from the University press services.

**CONCLUSION AND POLICY IMPLICATIONS**

We believe that this project will address some of the most pressing issues related to occupational injury surveillance and research. Despite some limitations, the inclusion of different studies within this project, using several methodologies, together with the power in numbers and high quality of

the data will allow us to explore trends and risks in occupational injuries in Sweden from many perspectives. The richness of our data will allow us to conduct several specialized sub studies in the future which have not been outlined here, and we would be happy to receive suggestions for further studies and invitations to collaborate.

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**Author Contributions**

CO has drafted previous versions and the final version of the manuscript. TB is the principal investigator of the project. BK, GJ, BB, KK, TH, MA, LD and DW participate in the project and have contributed to the design of the project and its studies. All authors have read and approved of the final version of the manuscript.

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**Competing interests**

The authors declare that they have no competing interests.

**Availability of data and material**

Data sharing not possible according to Swedish regulations.

**Ethics approval and consent to participate**

Ethical permission for the study for the project duration was granted by the Regional Ethics Committee, Stockholm (Dnr 2016/2325-31 and 2017/2173-32).

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# Precarious employment, business performance and occupational injuries – a study protocol of a register-based Swedish project.

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**ABSTRACT**

**Introduction:** There is uncertainty regarding the trends in occupational injuries (OI) in Sweden due to a significant and increasing problem with under-reporting to injury registers. Underreporting in general is likely to be exacerbated by the rise in precarious employment (PE), a set of unfavourable employment characteristics that would benefit from formal definition and study. PE and global trends are believed also to affect companies and their commitment to health and safety. The present study attempts to bridge these knowledge gaps and presents a study protocol for planned studies, with three main objectives: first, to review the literature for definitions of PE emphasizing those that are multi-dimensional and operationalize components in routinely collected register data; second, to estimate the under-reporting of OI in Swedish registers; and third, using results from the first objective, to conduct large, register-based prospective studies, designed to measure effect sizes and interactions between PE, business performance and OI.

**Methods and analysis:** First, a scientific literature review will be conducted, including scientific databases and grey literature. Second, data from two major OI registers will be used to estimate the magnitude of under-reporting using capture-recapture methodology. Finally, all residents aged 18-65 in Sweden with any registered income during 2003-2015 will be included. Data sources encompass Swedish population and labour market registers with linkage to both the main OI register with national coverage and hospital records. Trends in PE and OI will be explored, together with risk of OI associated to PE and business performance.

**Ethics and dissemination:** The project has been approved by the Regional Ethics Committee, Stockholm (dnr:2016/2325-31;2017/2173-32). Dissemination of study results will include a series of peer-reviewed papers, at least one PhD thesis and one report in Swedish, engaging relevant stakeholders. Results will be presented in national and international conferences and through press releases to mass media.

**Keywords:** Precarious employment, occupational injury, business performance, study protocol, register-based.

**Article Summary**

**Strengths and limitations of this study**

- We present a systematic approach to operationalization of the arising social determinant of health; precarious employment. This effort is much needed and is likely to be valuable to the research community.
- The use of high quality, nation-wide register data of covering the total working population provides power to the study and virtually zero loss to follow-up.
- A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias.
- There exists a potential risk of misclassification for both exposure and outcome, due to factors such as data availability and self-reporting.
- For the under-reporting of occupational injuries, the main limitation refers to differences in the coverage of the different data sources, which may limit our ability to make good estimates in some labour market sectors.

## INTRODUCTION

Setting priorities for workplace health and safety research depends upon accurate and reliable accident and injury data. In Norway and Denmark studies suggest that as few as 9-26% of all occupational accidents reaching hospitals are also reported to the national occupational injury registers. [1, 2] There is uncertainty regarding the trends in occupational injuries in Sweden due to under-reporting to Swedish injury registers. [3, 4] It is known that larger workplaces in Sweden generally have better routines for reporting occupational injuries than smaller companies. [4] Among the latter, there is a widespread poor awareness that reporting of occupational injuries is mandatory. No systematic analysis of the magnitude of under-reporting and factors associated with this problem has been performed.

The problem with under-reporting could be exacerbated by the rise in precarious employment, non-standard employment relations encompassing short-term and temporary contracts, as well as powerlessness, vulnerability, employment insecurity and insufficient wages. There is no internationally accepted definition of precarious employment, but several multidimensional constructs have been proposed. [5-7]

There is reason to believe that precariously employed workers are less likely to report occupational injuries due to lack of knowledge, education, unionization and empowerment in exercising rights. Precariously employed workers are also likely to be at higher risk of occupational injuries. A recent review by our group [8] supports an association between some of the dimensions of precarious employment and occupational injuries, most notably for multiple jobholders [9-12] and employees of temporary agencies or subcontractors at the same worksite. [13-15] Results for employees on fixed-term contracts were inconclusive.

The rise in non-standard employment relations is a trend in many countries in all stages of development and Sweden is no exception. Here, temporary employment rose during the nineties crisis and is especially common among young adults, where the proportion on temporary contracts

is 65% among both men and women aged 20-34. [16] Precarious employment and business performance are also likely to be intertwined. International trends in management and increased competition affect companies and their commitment to both health and safety and good employment conditions. In order to stay economically competitive and to earn maximum profits, it has been found that construction contractors only execute basic safety measures and eliminate many important hazard prevention training programs during project implementation. [17] Others have found that when the financial condition of a firm deteriorates, then it is likely to adopt policies that will lead to an increase in safety violations, accident rate, and environmental hazards. [18] In contrast, companies that prosper could be more likely to invest in occupational health and safety. In a study of U.S. coal mining companies a 10% increase in real total revenue per hour worked was associated with 0.9% decrease in the incidence rates of all reported injuries. [19] However, the relationship between business performance and the risk of occupational injuries remains largely unstudied, highlighting the importance of such a study.

Research regarding the association between precarious employment, business performance and occupational injuries faces several challenges. The employer-employee relationship is increasingly complex and there is mounting evidence that a single variable, such as temporary employment or job insecurity is not enough to explore this relationships association to health outcomes. [8, 20, 21] A multidimensional approach is needed, but the variety in definitions used makes comparison between studies and countries difficult. Which key business indicators that are useful in researching precarious businesses in relation to occupational injuries is unknown.

To address these challenges, ***the first objective*** of this project is to review the literature for multi-dimensional definitions of precarious employment and similar constructs and identify its main components. We will then suggest ways to operationalize these components in routinely collected register data.

There is a pressing need for better injury statistics in order to set priorities for prevention and future research. Therefore, ***the second objective*** of this study is to estimate the magnitude of under-reporting of injuries in Swedish registers and investigate which factors are related to this.

Finally, ***the third objective*** of this project is to use the results from our methodological work in the first objective to conduct large, register-based prospective studies, designed to identify trends on the labor market and measure effect sizes and interactions of the relationship between precarious employment, key business indicators and occupational injuries as well as their interaction with sociodemographic and economic indicators.

In this protocol we provide an overview of the data sources and methods to be used in the project.

**Specific Research Questions**

Studies are planned based on specific research questions (RQ) aligned to the overarching objectives above.

Objective 1

RQ1. How has precarious employment been previously defined and how can this be operationalized in Swedish registers?

Objective 2

RQ2. What is the magnitude of under-reporting of occupational injuries in Sweden 2013, and is under-reporting differential with respect to:

a. individual factors such as age, sex educational level and precarious employment status,
b. organizational-level factors such as company size, industry or sector, gender composition, age composition, and proportion of immigrant workers,
c. injury severity, and cause of accident?

Objective 3

RQ3. What are the trends in precarious employment in the Swedish labour market?

RQ4. What are the occupational injury trends over time for precarious workers and organizations or industries that go through economic change?

RQ5. Are precarious workers at higher risk of occupational injuries compared to others?

RQ6. Are changes in key business indicators risk factors for occupational accidents over short-term and long-term periods?

**Ethics**

The project has been approved by the Regional Ethics Committee, Stockholm (dnr: 2016/2325-31 and 2017/2173-32).

## METHODS AND ANALYSIS

### Patient and public involvement

Patients and/or members of the public have not been involved in the design of this study. Results from scientific publications will be shared with stakeholders, policy makers and social partners.

### Description of data sources

This study includes all residents aged 18-65 in Sweden with any registered income for at least one year, from January 1st 2003 through December 31st 2015. For the main analysis this cumulatively amounts to approximately 7 000 000 individuals over the years 2003-2015.This project will use the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA) with linkage to the Information System on Occupational Injuries (ISA) and hospital records, described in greater detail in Tables 1 and 2. We will use the unique personal identity number assigned to each resident in Sweden to link information from all the registers used in this project.

Statistics Sweden has removed the original personal identity number and replaced with a new, unique and unidentifiable identification number, thus ensuring the confidentiality of the information.

**Table 1.** Characteristics of the data sources used in this project to identify occupational injuries.

| Data Source | Population Covered | Injury reporting and definition | Eligibility, compensation and data access |
|---|---|---|---|
| Information System on Occupational Injuries (ISA)[a] | All employees and self-employed persons in Sweden.<br>To be employed in Sweden you need to be a resident (temporary or permanent) or EU citizen. EU-citizens can work without registering to the authorities for up to 6 months. Those directly employed in EU/ESS or third country but stationed in Sweden are not covered. | The employee is responsible for notifying the employer who in turn is obliged by law to report any injury. There is no deadline for reporting an injury. Reports are filed online and to a lesser extent on paper.<br>An occupational injury is 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. Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents. | Days of work lost due to the injury (except in the case of annuity) are paid through the regular sickness benefit system[b]. So, despite the law to report injuries, no report is needed to get compensation for lost work days.<br>If the injury is likely to reduce work-ability for more than 1-year, compensation for lost work income (annuity) can be approved if the injury has led to a lower income for the worker (other job and/or fewer hours).<br>ISA automatically sends the report to the national insurance board who administrates both the sickness benefit and worker's compensation. No assessment of the injuries validity is made unless the worker makes a claim for compensation.<br>Data access: Open and closed cases are available alike at the time of data extraction. Final statistics are published approximately 11 months after the close of the calendar year. |

| | | | |
|---|---|---|---|
| AFA insurance[b] | All employees within the private sector (also self-employed) who have signed a collective agreement. All employees in municipalities and county councils as they are always covered by collective agreements. AFA also administrates the occupational injury insurance for all national government employees. Thus, in total, the AFA register covers 100% of the public sector employees and approximately 90% of the total Swedish Labour market. The same regulations regarding employment in Sweden as described under ISA applies. | Employees report directly to AFA through an online form. There is no deadline for reporting an injury. However, there is a 10-year deadline to receive compensation (6 years for income loss) The same definition of occupational injury as ISA is used. | Eligibility: The employer confirms that the person was an employee at the time of the injury through a direct query from AFA. AFA also checks with the national insurance board if there are sick-days reported. The claim's validity is assessed and if granted compensation can be given for lost income, direct costs associated to the injury and sometimes compensation for pain and suffering. If the injury still causes suffering after 18 months, compensation can be given for medical disability/permanent impairment and/or annuity.<br><br>Data access: Open and closed cases are available alike at the time of data extraction. |
| [a] ISA register is held by the Swedish Work Environment Agency[b] Special cases (workers who do not qualify for sickness benefit or if his/her sickness benefit is low) are covered by the occupational injury sickness benefit.<br>[c] AFA is a privately held insurance company owned by the Swedish trade unions and employer's organizations. Available data for the year 2013. | | | |

Apart from the data sources described above, for the second objective we will also include occupational injuries that occurred in the year 2013 using data from AFA Insurance, an organization owned by the Swedish labour market parties (Table 1).

**Table 2.** Additional sources of data used in this project.

| Data Source | Population covered | Available variables | Timeliness |
|---|---|---|---|
| Longitudinal Integration database for health insurance | It holds annual registers since 1990 and includes all individuals 16 years of age and older who were | The database integrates multiple databases from the labour market, | Temporal resolution: Variables are on yearly basis for both individuals and |

| | | | |
|---|---|---|---|
| and labour market studies (LISA) [a] | registered in Sweden as of December 31 for each year. | educational and social sectors. It contains not only individual data, but also connections to family, companies and places of employment. | businesses, this applies to e.g. income, revenue, etc.<br><br>Multiple employers are registered (total number and details on the three major employers).<br><br>Data access: Data is compiled with an 18 months' lag. |
| National Patient Register (NPR) [b] | All visits to inpatient or specialised outpatient care (i.e. excluding primary care). | Our dataset includes every person who was diagnosed with external cause of injury (ICD10 chapters S and T). Duration of hospitalization will be used to characterize severity. | All hospitals and specialized outpatient clinics in Sweden report to a central register, coverage is >95%.<br><br>Data includes exact date of visits admission and discharge. |
| Cause of Death Register (DR) [b] | It includes all those who died during one calendar year and were registered in Sweden at the time of death, regardless of whether the death occurred inside or outside the country.[c] | It shows the underlying cause of death coded according to the international version of the disease classification ICD-10. For injuries, the external cause of injury is shown. | Reported by physician no later than 3 weeks after death. |
| [a] LISA is held by Statistics Sweden. [b] NPR and DR are held by the National Board of Health and Welfare. [c] The statistics do not include stillborns, persons who died on a temporary visit to Sweden or asylum seekers who have not yet obtained residence permits. Swedes who have emigrated and are no longer registered in Sweden are not included either. | | | |

**Main variables**

Precarious Employment and Key Business Indicators:

The definition of precarious employment will be developed through the systematic literature review, development of a functional PE definition applicable to available registers and then operationalization in registers (RQ1). Information on exposure to precarious employment and key business indicators will be constructed from data obtained through the LISA register (Table 2).

Relevant key business indicators will be selected though discussions and workshops within the research team, which includes a business economist. There is very limited guidance in previous

research on which key business indicators could be related to occupational injuries. Under the well-founded assumption that managers make decisions (including those affecting health and safety) based on the projected future of the company, the initial work has focused on identifying key indicators of company value, as reflected by operating assets, future earnings and cash flows. Preliminary discussions suggest that return on equity, operating margin, net turnover/employee, employee costs/net turnover, solidity, operating result/employee, employee costs/employee, financial leverage, labour costs as well as total gross and net investments are highly relevant. All these variables are available directly from LISA for all Swedish companies. Stock market prices have been contemplated but discarded since most companies are not listed. We also have ongoing work identifying which key business indicators that are useful in comparing companies across industries and within specific industries. We will most likely adopt an exploratory approach on a subset of the dataset before deciding on which indicators to use.

Occupational Injuries:

Information on occupational injuries caused by an accident is being obtained from two different Swedish registers: ISA and AFA Insurance (Table 1). By linking Swedish population and labour market registers together with hospital records, we will be able to characterize injuries in terms of severity and add information on potential confounders.

Occupational Injury Definition:

We will use the definition used in Swedish Law and which is applied by both the ISA and AFA registers. *"An occupational injury is 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.*

*Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation*

*and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents." [22]*

Since estimating under-reporting is one of our main objectives, we will study reported occupational injuries. In ISA, claims can only be made for a limited set of compensations (Table 1). No assessment of reports is made without a claim; thus an inclusion of claims or approved claims would be too limiting. The occurrence of false reports is thought to be very low (personal communication with the work environment authority) and is likely random. However, we will explore this issue further.

Moreover, we will exclude injuries that occurred during transit to/from work, occupational diseases and near injuries.

*Occupational Injury severity*

Severity of occupational injuries will be assessed in two different ways.

Days of work lost: Data from the Swedish Social Insurance Agency provided by employers and part of the ISA and AFA registers, will be used to obtain days lost from work due to sickness absence and disability pension, in connection with occupational injuries. This information covers all employees.

Specialized care, Hospitalisation and Death: Specialized care, hospitalization and death will be obtained from the National Patient Register (NPR) and Cause of death register (DR) (Table 2). We have limited this study to chapters S and T in International Classification of Disease 10 (ICD-10) which contain injuries, poisoning and some other consequences of external causes. Since all diagnoses are not covered, this dataset does not include all occupational injuries leading to specialized care, hospitalization and death. Regarding injuries to the musculoskeletal system, it only covers fractures, dislocations and distortions. However, it will allow a subpopulation analysis of severe acute injuries in RQ2-6.

*Linkage of data sources*

The unique personal identity number assigned to each resident in Sweden, enables the linkage of information from all the registers mentioned above. Also, there is an identification number specific for each company and workplace within companies, which will allow us to conduct a 3-level analysis (individuals, workplaces and companies). This linkage will provide aggregate exposure data, such as company-specific characteristics related to individuals, number of employees at each workplace, etc. We will also be able to follow individuals moving between workplaces.

For objective 2 specifically, occupational injury registers (AFA and ISA) have been linked on a +/-7 day's range basis, which means that accidents reported within a week in either register were considered to be the same. We present preliminary results for this linkage. Data from the NPR will be linked using the same criteria (+/-7 day's range), using injury date from the occupational injury registers and admission date from both in- and out-patient registers. Finally, data on socio demographic characteristics, key business indicators and all relevant covariates will be added from the LISA register.

**Covariates/Confounders**

We will use information from LISA register (Table 2) to adjust for confounding factors, perform stratified analyses and sub-group analyses.

Individual: age, sex, educational level, income, country of birth (four groups: Sweden, other Nordic country, other EU 25, and rest of the world) and occupation according to the Swedish Standard Classification of Occupations (SSYK 1996), [23] which is based on the International Standard Classification of Occupations 1988 (ISCO-88). All analyses will be stratified by sex and age.

Workplace: In addition to key business indicators, we have information on workplace level on industry (Swedish Standard Industrial Classification), [24] number of employees, educational level of workforce and workplace sex distribution.

**Analysis plan**

Definitions and operationalization of precarious employment (RQ1)

We will deconstruct all definitions obtained by our literature search into single dimensions and perform a qualitative and quantitative appraisal of their appropriateness. Based on our findings, we will propose a core set of variables that should be included in a multidimensional definition of precarious employment depending on data availability. Once these are defined, we will operationalize a multidimensional definition in Swedish registers to be able to use it in the subsequent studies and develop a job exposure matrix for precarious employment including these variables (study 1).

Under-reporting of occupational injuries (RQ2)

In order to estimate the magnitude of under-reporting of occupational injuries for the year 2013 (RQ6), two sources of data on occupational injures (ISA and AFA registers) will be used to obtain estimates by means of capture-recapture methodology (study 2). This method, based on log-linear models, has been successfully used by others and it is used to estimate the incomplete ascertainment using information from overlapping lists of cases from distinct sources. [25] We will conduct stratified analyses by precarious employment status, based on results from RQ1.

Trends in precarious employment and occupational injuries (RQ3 and RQ4)

Using data from the whole study period, we will then explore trends in precarious employment over time in Sweden, for the years 2003-2015 (as laid out in study 1). We will put special attention to changes over time for women and men, different industries, and foreign born compared to Swedish born (study 3).

We will also explore the trends over time with regards to the risk for occupational injuries for precarious workers and organizations or industries in economic trouble (study 4).

Risk of injury associated to precarious employment (RQ5)

Precarious employment, as defined though formative work in study 1, will be the independent variable of interest in a multivariate analysis with occupational injury as the outcome. It is well known that the risk of occupational injuries decreases with tenure at any given job. It is unlikely that there is an accumulation of risk or latency in the precarious employment–occupational injuries relationship. We will therefore measure risk and outcome at the same point in time, i.e. precarious employment and injury in the same year. We will also explore the interaction effects of age and tenure/experience. Analysis will be adjusted for socio-demographic variables. A longitudinal dimension will be introduced by analyzing the changes in risks over the time of the study period (2003-2015). Due to the large differences in risk of injury based on occupation, sector and industry, we will perform stratified analysis based on these variables. Apart from this, we will provide the population attributable fraction as part of our results.

The outcome will be stratified based on severity of injury and differences in risk of injury severity between precarious and non-precarious employees will be explored.

Risk of injury associated to key business indicators (RQ6)

A cohort of all Swedish companies will be created. The outcome will be defined as occupational injury per full-time employee and calculated for each year for each individual company. We will calculate short-term (1 year) and long-term (5-year) trajectories in key business indicators for each company and use these as the main independent variables of interest in a multivariate regression analysis. Stratified analysis will be carried out based on company size, industry/sector. As in RQ5, the outcome will be stratified based on severity of injury and the population attributable fraction will be calculated.

**Preliminary findings**

In this protocol we present preliminary findings based on linkage of different data sources for the working population aged 18-65 years, during the year 2013. The total number of occupational injuries reported only in AFA, only in ISA as well as the overlap (presence in both registers) are shown in Table 3. Linkage between AFA and ISA registers for this preliminary analysis was conducted on id-number (de-identified) and injury date, on a +/- 7 days' range. There was approximately a 36% overlap between the two data sources.

**Table 3.** Number of occupational accidents reported to either ISA, AFA or both (overlap)*, together with presence in the National Patient Register (in- and out-patient), for the year 2013 in Sweden.

| | All reported injuries | | Total NPR | | In-patient | | Out-patient | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| ISA only | 49 356 | 47,6 | 5 343 | 10,8 | 368 | 0,7 | 4 975 | 10,1 |
| AFA only | 17 095 | 16,5 | 4 458 | 26,1 | 371 | 2,2 | 4 087 | 23,9 |
| ISA and AFA | 37 138 | 35,9 | 10 131 | 27,3 | 1 119 | 3,0 | 9 012 | 24,3 |
| Total | 103 589 | 100,0 | 19 932 | 19,2 | 1 858 | 1,8 | 18 074 | 17,4 |

**Linkage of datasets conducted on id-number (de-identified) and injury date in a +/-7 days' range.*
*NPR= National Patient Register*

**DISCUSSION**

In this project we aim at operationalizing precarious employment in Swedish labor market registers and use this definition to conduct several large, register-based prospective etiological studies, designed to measure effect sizes and interactions of the relation between precarious employment, business performance and occupational injuries. Taking advantage of two separate and comprehensive reporting systems for occupational injuries in Sweden we will also estimate under-reporting of occupational injuries and the factors which are related to this issue. In this protocol, we present preliminary results for the overlapping of occupational injuries for the year 2013.

**Strengths and limitations**

We believe that the major strength of our project will arise from the results from the first study, i.e. the operationalization of precarious employment. This, together with the identification of key

business indicators of relevance for the association between precariousness and occupational injuries can be considered as a valuable start point for future research investigating these factors.

By using the unique Swedish personal and organisation identification numbers from ISA and LISA we are able to link both individuals and companies to each other and to the injury databases. The use of high quality, nationwide register data covering the total working population provides power to the study and virtually zero loss to follow-up. A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias. Information on sickness absence and hospitalization allows us to characterize our outcome in terms of severity, further adding quality aspects to outcome measurement.

However, some limitations and methodological challenges should be addressed.

Occupational injury definition:

The system of self-reporting and somewhat ambiguous definition of occupational injury introduces the risk of misclassification between occupational injury and disease. This problem is likely to be most serious in the case of musculoskeletal disorders (MSDs) where repeated over-exertion leading to an MSD could be reported as both an occupational injury and occupational disease. For women, over-exertion injuries (physical over-exertion such as during heavy lifting and carrying, jerks, slips) constituted the second most common cause/type of occupational injury with at least one day of sickness absence in Sweden. [26] For men it was the third most common cause. If the misclassification was random and steady over time this would pose a lesser problem, but we have reason to believe that the preference to choose between reporting MSDs as injuries or diseases might be biased by preconceptions about chances of getting a claim granted in either category and that this changes over time as a consequence of regulatory changes.

Additionally, there is risk of including "non-occupational" injuries while investigating reports rather than approved claims. The rationale for not limiting the reports to approved injuries is that the rules for receiving compensation have been tightened over the last decade and we believe that on the group level, there is more consistency over time in employees' notion of what qualifies as an occupational injury than in the assessment by the social insurance agency. In personal communication with civil servants at the Swedish Work Environment Authority, the presence of non-occupational injuries has been deemed "an issue in the margin".

Finally, although the occurrence of traffic-related injuries is increasing in some countries, [27] we decided to exclude those from our study. Injuries that occurred during transit to/from work may be covered by car insurances and may therefore not appear in the occupational injury registers.

Injury severity:

In Sweden, sickness absence is reimbursed by the Swedish Social Insurance Agency starting on day 15. The near universal coverage of the regular sickness insurance scheme and the additional coverage specifically for injuries makes us rather confident that we will be able to identify most serious injuries occurring in the formal labour market. The other severity measure obtained through hospital records only covers injuries, poisoning and some other consequences of external causes (S and T chapters in ICD-10). Thereby, we will not identify major injury categories such as acute lumbago (M45.3).

Whether we characterize severity in terms of days of hospitalization or reimbursed days lost of work, we have a rather large difference between mild and severe cases, losing the broad spectrum of less severe injuries while severe cases can be classified in more detail.

Precarious employees:

Although we have not yet operationalized precarious employment in registers, we foresee some constraints. Among other issues, type of contract (permanent/temporary) is not registered and will

have to be constructed by proxy variables with lower specificity. EU citizens stationed in Sweden and informal workers are not covered in this study, groups that are of special interest in research on precarious employment. This is a major limitation, but the constraints in data do not allow us to study these two categories of potentially precarious workers.

Precarious employees are less likely to be covered by collective agreements and therefore the issue will be greatest here. We also hypothesise that they are less likely to report injuries. This will affect both our analysis of under-reporting using capture-recapture, and also the estimates for the association between precarious employment and the risk of occupational injuries.

Key business indicators:

Previous studies have found that as the financial condition of a firm deteriorates, it is likely to adopt policies that will lead to an increase in safety violations, accident rate, and in environmental hazards [18] and that when revenue increases the opposite would occur. [19] The opposite might however be true as well. As revenue falls, the work tempo might shift downwards temporarily and the short-term effects on injuries might be positive. Lay-offs of those with least tenure may also leave a larger proportion of experienced workers which could lead to fewer injuries. Mirroring this; as revenue increases in a company, new employees come in who are at higher risk. Disentangling these effects and counter effects of changes in key business indicators will be a major challenge and will require important formative work on causal pathways and the construction of logic models prior to analysis. Due to the lack of prior research in this area, an exploratory approach using data-mining or machine learning algorithms will also be applied to discover risk factors and pathways which we cannot foresee at the moment.

Working hours:

When calculating risk of occupational injuries, a measure of working hours is needed as denominator in order to make just comparisons. Lacking data on individual working hours in this project we have

to rely on proxy variables to make estimations. Due to collective bargaining the wage structure in Sweden is rather homogenous, especially for blue collar workers and white collar workers with low skills. We are currently exploring the feasibility of using wage in combination with occupational code and industry code as well as the public registers on median salaries in certain occupations (survey-based information) to create a proxy for fulltime employment based on the deviation from the median wage.

Formal/informal work:

As this study partly focuses on precarious employment, we need to spell out that this study is only investigating the formal economy. Not including people working in the informal sector completely or partly will be one of our major limitations. According to the 2015 European Working Conditions Survey (EWCS), the prevalence of informal employment for Sweden is estimated to be 5%, lying below the average for the European union (10%). [28] Those who are formally employed but receive part of their salary “under the table” will be especially at high risk of being misclassified. Also, foreign citizens working in Sweden but whose employer is registered in another country will be absent in this study. We know that these workers are very common in construction and logistics, two industries with high risk of injury.

Under-reporting:

Capture-recapture is a method that has been widely used in epidemiology to estimate unknown size of populations. Methodological issues may appear from dependence among data sources being used to obtain estimates. [25] When it comes to occupational diseases, AFA requires that a report is made first to ISA, therefore one would expect a high level of dependency and that AFA would be completely nested in ISA. For occupational injuries, this is not the case and there is a large proportion of injuries that are only reported to AFA. This said, the detected dependency may result in an overestimation of the true population size, and we must therefore treat our estimations cautiously.

Also, the AFA insurance scheme is not as comprehensive as ISA's. The ISA register covers 100% of the employees and self-employed while the AFA register covers 100% of public sector employees and all employees within the private sector who have signed a collective agreement. However, collective agreements are less common in small companies and certain industries such as hospitality where 45% of the companies have collective agreements. This will limit our ability to make good estimates in some labour market sectors.

Finally, under-reporting of occupational injuries may be higher among precarious workers, and conversely, these workers may have a higher rate of injuries compared to non-precarious workers. To be able to observe differences in the under-reporting for precarious workers compared to non-precarious, we will conduct stratified analyses.

**DISSEMINATION**

The project is presently planned to result in a series of papers published in international peer-reviewed scientific journals, at least one PhD thesis and a report in Swedish aimed at relevant stakeholders including governmental agencies, policy-makers and social partners (employers and trade unions). Due to the richness of the data obtained and the multiple scientific approaches we anticipate that the project will result also in further publications than those outlined in this protocol, including future collaborations. Results of public interest will be formatted as press releases and sent to Swedish and international media with support from the University press services.

**CONCLUSION AND POLICY IMPLICATIONS**

We believe that this project will address some of the most pressing issues related to occupational injury surveillance and research. Despite some limitations, the inclusion of different studies within this project, using several methodologies, together with the statistical and high quality of the data will allow us to explore trends and risks in occupational injuries in Sweden from many perspectives. The richness of our data will allow us to conduct several specialized sub studies in the future which

have not been outlined here, and we would be happy to receive suggestions for further studies and invitations to collaborate.

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**Author Contributions**

CO has drafted previous versions and the final version of the manuscript. TB is the principal investigator of the project. BK, GJ, BB, KK, TH, MA, LD and DW participate in the project and have contributed to the design of the project and its studies. All authors have read and approved of the final version of the manuscript.

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**Competing interests**

None declared.

**Availability of data and material**

Data sharing not possible according to Swedish regulations.

**Ethics approval and consent to participate**

Ethical permission for the study for the project duration was granted by the Regional Ethics Committee, Stockholm (Dnr 2016/2325-31 and 2017/2173-32).

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# Precarious employment, business performance and occupational injuries – a study protocol of a register-based Swedish project.

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## ABSTRACT

**Introduction:** There is uncertainty regarding the trends in occupational injuries (OI) in Sweden due to a significant and increasing problem with under-reporting to injury registers. Underreporting in general is likely to be exacerbated by the rise in precarious employment (PE), a set of unfavourable employment characteristics that would benefit from formal definition and study. PE and global trends are believed also to affect companies and their commitment to health and safety. The present study attempts to bridge these knowledge gaps and presents a study protocol for planned studies, with three main objectives: first, to review the literature for definitions of PE emphasizing those that are multi-dimensional and operationalize components in routinely collected register data; second, to estimate the under-reporting of OI in Swedish registers; and third, using results from the first objective, to conduct large, register-based prospective studies, designed to measure effect sizes and interactions between PE, business performance and OI.

**Methods and analysis:** First, a scientific literature review will be conducted, including scientific databases and grey literature. Second, data from two major OI registers will be used to estimate the magnitude of under-reporting using capture-recapture methodology. Finally, all residents aged 18-65 in Sweden with any registered income during 2003-2015 will be included. Data sources encompass Swedish population and labour market registers with linkage to both the main OI register with national coverage and hospital records. Trends in PE and OI will be explored, together with risk of OI associated to PE and business performance.

**Ethics and dissemination:** The project has been approved by the Regional Ethics Committee, Stockholm (dnr:2016/2325-31;2017/2173-32). Dissemination of study results will include a series of peer-reviewed papers, at least one PhD thesis and one report in Swedish, engaging relevant stakeholders. Results will be presented in national and international conferences and through press releases to mass media.

**Keywords:** Precarious employment, occupational injury, business performance, study protocol, register-based.

**Article Summary**

**Strengths and limitations of this study**

- We present a systematic approach to operationalization of the arising social determinant of health; precarious employment. This effort is much needed and is likely to be valuable to the research community.
- The use of high quality, nation-wide register data of covering the total working population provides power to the study and virtually zero loss to follow-up.
- A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias.
- There exists a potential risk of misclassification for both exposure and outcome, due to factors such as data availability and self-reporting.
- For the under-reporting of occupational injuries, the main limitation refers to differences in the coverage of the different data sources, which may limit our ability to make good estimates in some labour market sectors.

## INTRODUCTION

Setting priorities for workplace health and safety research depends upon accurate and reliable accident and injury data. In Norway and Denmark studies suggest that as few as 9-26% of all occupational accidents reaching hospitals are also reported to the national occupational injury registers. [1, 2] There is uncertainty regarding the trends in occupational injuries in Sweden due to under-reporting to Swedish injury registers. [3, 4] It is known that larger workplaces in Sweden generally have better routines for reporting occupational injuries than smaller companies. [4] Among the latter, there is a widespread poor awareness that reporting of occupational injuries is mandatory. No systematic analysis of the magnitude of under-reporting and factors associated with this problem has been performed.

The problem with under-reporting could be exacerbated by the rise in precarious employment, non-standard employment relations encompassing short-term and temporary contracts, as well as powerlessness, vulnerability, employment insecurity and insufficient wages. There is no internationally accepted definition of precarious employment, but several multidimensional constructs have been proposed. [5-7]

There is reason to believe that precariously employed workers are less likely to report occupational injuries due to lack of knowledge, education, unionization and empowerment in exercising rights. Precariously employed workers are also likely to be at higher risk of occupational injuries. A recent review by our group [8] supports an association between some of the dimensions of precarious employment and occupational injuries, most notably for multiple jobholders [9-12] and employees of temporary agencies or subcontractors at the same worksite. [13-15] Results for employees on fixed-term contracts were inconclusive.

The rise in non-standard employment relations is a trend in many countries in all stages of development and Sweden is no exception. Here, temporary employment rose during the nineties crisis and is especially common among young adults, where the proportion on temporary contracts

is 65% among both men and women aged 20-34. [16] Precarious employment and business performance are also likely to be intertwined. International trends in management and increased competition affect companies and their commitment to both health and safety and good employment conditions. In order to stay economically competitive and to earn maximum profits, it has been found that construction contractors only execute basic safety measures and eliminate many important hazard prevention training programs during project implementation. [17] Others have found that when the financial condition of a firm deteriorates, then it is likely to adopt policies that will lead to an increase in safety violations, accident rate, and environmental hazards. [18] In contrast, companies that prosper could be more likely to invest in occupational health and safety. In a study of U.S. coal mining companies a 10% increase in real total revenue per hour worked was associated with 0.9% decrease in the incidence rates of all reported injuries. [19] However, the relationship between business performance and the risk of occupational injuries remains largely unstudied, highlighting the importance of such a study.

Research regarding the association between precarious employment, business performance and occupational injuries faces several challenges. The employer-employee relationship is increasingly complex and there is mounting evidence that a single variable, such as temporary employment or job insecurity is not enough to explore this relationships association to health outcomes. [8, 20, 21] A multidimensional approach is needed, but the variety in definitions used makes comparison between studies and countries difficult. Which key business indicators that are useful in researching precarious businesses in relation to occupational injuries is unknown.

To address these challenges, ***the first objective*** of this project is to review the literature for multi-dimensional definitions of precarious employment and similar constructs and identify its main components. We will then suggest ways to operationalize these components in routinely collected register data.

There is a pressing need for better injury statistics in order to set priorities for prevention and future research. Therefore, ***the second objective*** of this study is to estimate the magnitude of under-reporting of injuries in Swedish registers and investigate which factors are related to this.

Finally, ***the third objective*** of this project is to use the results from our methodological work in the first objective to conduct large, register-based prospective studies, designed to identify trends on the labor market and measure effect sizes and interactions of the relationship between precarious employment, key business indicators and occupational injuries as well as their interaction with sociodemographic and economic indicators.

In this protocol we provide an overview of the data sources and methods to be used in the project.

**Specific Research Questions**

Studies are planned based on specific research questions (RQ) aligned to the overarching objectives above.

Objective 1

RQ1. How has precarious employment been previously defined and how can this be operationalized in Swedish registers?

Objective 2

RQ2. What is the magnitude of under-reporting of occupational injuries in Sweden 2013, and is under-reporting differential with respect to:

a. individual factors such as age, sex educational level and precarious employment status,
b. organizational-level factors such as company size, industry or sector, gender composition, age composition, and proportion of immigrant workers,
c. injury severity, and cause of accident?

Objective 3

RQ3. What are the trends in precarious employment in the Swedish labour market?

RQ4. What are the occupational injury trends over time for precarious workers and organizations or industries that go through economic change?

RQ5. Are precarious workers at higher risk of occupational injuries compared to others?

RQ6. Are changes in key business indicators risk factors for occupational accidents over short-term and long-term periods?

**Ethics**

The project has been approved by the Regional Ethics Committee, Stockholm (dnr: 2016/2325-31 and 2017/2173-32).

## METHODS AND ANALYSIS

### Patient and public involvement

Patients and/or members of the public have not been involved in the design of this study. Results from scientific publications will be shared with stakeholders, policy makers and social partners.

### Description of data sources

This study includes all residents aged 18-65 in Sweden with any registered income for at least one year, from January 1st 2003 through December 31st 2015. For the main analysis this cumulatively amounts to approximately 7 000 000 individuals over the years 2003-2015.This project will use the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA) with linkage to the Information System on Occupational Injuries (ISA) and hospital records, described in greater detail in Tables 1 and 2. We will use the unique personal identity number assigned to each resident in Sweden to link information from all the registers used in this project.

Statistics Sweden has removed the original personal identity number and replaced with a new, unique and unidentifiable identification number, thus ensuring the confidentiality of the information.

**Table 1.** Characteristics of the data sources used in this project to identify occupational injuries.

| Data Source | Population Covered | Injury reporting and definition | Eligibility, compensation and data access |
|---|---|---|---|
| Information System on Occupational Injuries (ISA)[a] | All employees and self-employed persons in Sweden.<br>To be employed in Sweden you need to be a resident (temporary or permanent) or EU citizen. EU-citizens can work without registering to the authorities for up to 6 months. Those directly employed in EU/ESS or third country but stationed in Sweden are not covered. | The employee is responsible for notifying the employer who in turn is obliged by law to report any injury. There is no deadline for reporting an injury. Reports are filed online and to a lesser extent on paper.<br>An occupational injury is 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. Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents. | Days of work lost due to the injury (except in the case of annuity) are paid through the regular sickness benefit system[b]. So, despite the law to report injuries, no report is needed to get compensation for lost work days.<br>If the injury is likely to reduce work-ability for more than 1-year, compensation for lost work income (annuity) can be approved if the injury has led to a lower income for the worker (other job and/or fewer hours).<br>ISA automatically sends the report to the national insurance board who administrates both the sickness benefit and worker's compensation. No assessment of the injuries validity is made unless the worker makes a claim for compensation.<br>Data access: Open and closed cases are available alike at the time of data extraction. Final statistics are published approximately 11 months after the close of the calendar year. |

| | | | |
|---|---|---|---|
| AFA insurance[b] | All employees within the private sector (also self-employed) who have signed a collective agreement. All employees in municipalities and county councils as they are always covered by collective agreements. AFA also administrates the occupational injury insurance for all national government employees. Thus, in total, the AFA register covers 100% of the public sector employees and approximately 90% of the total Swedish Labour market. The same regulations regarding employment in Sweden as described under ISA applies. | Employees report directly to AFA through an online form. There is no deadline for reporting an injury. However, there is a 10-year deadline to receive compensation (6 years for income loss) The same definition of occupational injury as ISA is used. | Eligibility: The employer confirms that the person was an employee at the time of the injury through a direct query from AFA. AFA also checks with the national insurance board if there are sick-days reported. The claim's validity is assessed and if granted compensation can be given for lost income, direct costs associated to the injury and sometimes compensation for pain and suffering. If the injury still causes suffering after 18 months, compensation can be given for medical disability/permanent impairment and/or annuity.<br><br>Data access: Open and closed cases are available alike at the time of data extraction. |
| [a] ISA register is held by the Swedish Work Environment Agency[b] Special cases (workers who do not qualify for sickness benefit or if his/her sickness benefit is low) are covered by the occupational injury sickness benefit.<br>[c] AFA is a privately held insurance company owned by the Swedish trade unions and employer's organizations. Available data for the year 2013. | | | |

Apart from the data sources described above, for the second objective we will also include occupational injuries that occurred in the year 2013 using data from AFA Insurance, an organization owned by the Swedish labour market parties (Table 1).

**Table 2.** Additional sources of data used in this project.

| Data Source | Population covered | Available variables | Timeliness |
|---|---|---|---|
| Longitudinal Integration database for health insurance | It holds annual registers since 1990 and includes all individuals 16 years of age and older who were | The database integrates multiple databases from the labour market, | Temporal resolution: Variables are on yearly basis for both individuals and |

| | | | |
|---|---|---|---|
| and labour market studies (LISA) [a] | registered in Sweden as of December 31 for each year. | educational and social sectors. It contains not only individual data, but also connections to family, companies and places of employment. | businesses, this applies to e.g. income, revenue, etc.<br><br>Multiple employers are registered (total number and details on the three major employers).<br><br>Data access: Data is compiled with an 18 months' lag. |
| National Patient Register (NPR) [b] | All visits to inpatient or specialised outpatient care (i.e. excluding primary care). | Our dataset includes every person who was diagnosed with external cause of injury (ICD10 chapters S and T). Duration of hospitalization will be used to characterize severity. | All hospitals and specialized outpatient clinics in Sweden report to a central register, coverage is >95%.<br><br>Data includes exact date of visits admission and discharge. |
| Cause of Death Register (DR) [b] | It includes all those who died during one calendar year and were registered in Sweden at the time of death, regardless of whether the death occurred inside or outside the country.[c] | It shows the underlying cause of death coded according to the international version of the disease classification ICD-10. For injuries, the external cause of injury is shown. | Reported by physician no later than 3 weeks after death. |
| [a] LISA is held by Statistics Sweden. [b] NPR and DR are held by the National Board of Health and Welfare. [c] The statistics do not include stillborns, persons who died on a temporary visit to Sweden or asylum seekers who have not yet obtained residence permits. Swedes who have emigrated and are no longer registered in Sweden are not included either. | | | |

**Main variables**

Precarious Employment and Key Business Indicators:

The definition of precarious employment will be developed through the systematic literature review, development of a functional PE definition applicable to available registers and then operationalization in registers (RQ1). Available variables regarding precarious employment and key business indicators from the OI registers are limited. Because of this, we will mainly obtain them through the LISA register (Table 2).

Relevant key business indicators will be selected though discussions and workshops within the research team, which includes a business economist. There is very limited guidance in previous research on which key business indicators could be related to occupational injuries. Under the well-founded assumption that managers make decisions (including those affecting health and safety) based on the projected future of the company, the initial work has focused on identifying key indicators of company value, as reflected by operating assets, future earnings and cash flows. Preliminary discussions suggest that return on equity, operating margin, net turnover/employee, employee costs/net turnover, solidity, operating result/employee, employee costs/employee, financial leverage, labour costs as well as total gross and net investments are highly relevant. All these variables are available directly from LISA for all Swedish companies. Stock market prices have been contemplated but discarded since most companies are not listed. We also have ongoing work identifying which key business indicators that are useful in comparing companies across industries and within specific industries. We will most likely adopt an exploratory approach on a subset of the dataset before deciding on which indicators to use.

Occupational Injuries:

Information on occupational injuries caused by an accident is being obtained from two different Swedish registers: ISA and AFA Insurance (Table 1). By linking Swedish population and labour market registers together with hospital records, we will be able to characterize injuries in terms of severity and add information on potential confounders.

Occupational Injury Definition:

We will use the definition used in Swedish Law and which is applied by both the ISA and AFA registers. *"An occupational injury is 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.*

*Injuries caused by threats, assaults, robberies, etc., are also counted as occupational injuries. Both physical and mental injuries are counted here. Injuries such as heat stroke, frostbite, inflammation and injuries due to mechanical effects for a shorter period of time, no more than a few days, are also considered to be caused by accidents." [22]*

Since estimating under-reporting is one of our main objectives, we will study reported occupational injuries. In ISA, claims can only be made for a limited set of compensations (Table 1). No assessment of reports is made without a claim; thus an inclusion of claims or approved claims would be too limiting. The occurrence of false reports is thought to be very low (personal communication with the work environment authority) and is likely random. However, we will explore this issue further.

Moreover, we will exclude injuries that occurred during transit to/from work, occupational diseases and near injuries.

*Occupational Injury severity*

Severity of occupational injuries will be assessed in two different ways.

Days of work lost: Data from the Swedish Social Insurance Agency provided by employers and part of the ISA and AFA registers, will be used to obtain days lost from work due to sickness absence and disability pension, in connection with occupational injuries. This information covers all employees.

Specialized care, Hospitalisation and Death: Specialized care, hospitalization and death will be obtained from the National Patient Register (NPR) and Cause of death register (DR) (Table 2). We have limited this study to chapters S and T in International Classification of Disease 10 (ICD-10) which contain injuries, poisoning and some other consequences of external causes. Since all diagnoses are not covered, this dataset does not include all occupational injuries leading to specialized care, hospitalization and death. Regarding injuries to the musculoskeletal system, it only covers fractures, dislocations and distortions. However, it will allow a subpopulation analysis of severe acute injuries in RQ2-6.

*Linkage of data sources*

The unique personal identity number assigned to each resident in Sweden, enables the linkage of information from all the registers mentioned above. Also, there is an identification number specific for each company and workplace within companies, which will allow us to conduct a 3-level analysis (individuals, workplaces and companies). This linkage will provide aggregate exposure data, such as company-specific characteristics related to individuals, number of employees at each workplace, etc. We will also be able to follow individuals moving between workplaces.

For objective 2 specifically, occupational injury registers (AFA and ISA) have been linked on a +/-7 day's range basis, which means that accidents reported within a week in either register were considered to be the same. We present preliminary results for this linkage. Data from the NPR will be linked using the same criteria (+/-7 day's range), using injury date from the occupational injury registers and admission date from both in- and out-patient registers. Finally, data on socio demographic characteristics, key business indicators and all relevant covariates will be added from the LISA register.

**Covariates/Confounders**

We will use information from LISA register (Table 2) to adjust for confounding factors, perform stratified analyses and sub-group analyses.

Individual: age, sex, educational level, income, country of birth (four groups: Sweden, other Nordic country, other EU 25, and rest of the world) and occupation according to the Swedish Standard Classification of Occupations (SSYK 1996), [23] which is based on the International Standard Classification of Occupations 1988 (ISCO-88). All analyses will be stratified by sex and age.

Workplace: In addition to key business indicators, we have information on workplace level on industry (Swedish Standard Industrial Classification), [24] number of employees, educational level of workforce and workplace sex distribution.

**Analysis plan**

Definitions and operationalization of precarious employment (RQ1)

We will deconstruct all definitions obtained by our literature search into single dimensions and perform a qualitative and quantitative appraisal of their appropriateness. Based on our findings, we will propose a core set of variables that should be included in a multidimensional definition of precarious employment depending on data availability. Once these are defined, we will operationalize a multidimensional definition in Swedish registers to be able to use it in the subsequent studies and develop a job exposure matrix for precarious employment including these variables (study 1).

Under-reporting of occupational injuries (RQ2)

In order to estimate the magnitude of under-reporting of occupational injuries for the year 2013 (RQ6), two sources of data on occupational injures (ISA and AFA registers) will be used to obtain estimates by means of capture-recapture methodology (study 2). This method, based on log-linear models, has been successfully used by others and it is used to estimate the incomplete ascertainment using information from overlapping lists of cases from distinct sources. [25] We will conduct stratified analyses by precarious employment status, based on results from RQ1.

Trends in precarious employment and occupational injuries (RQ3 and RQ4)

Using data from the whole study period, we will then explore trends in precarious employment over time in Sweden, for the years 2003-2015 (as laid out in study 1). We will put special attention to changes over time for women and men, different industries, and foreign born compared to Swedish born (study 3).

We will also explore the trends over time with regards to the risk for occupational injuries for precarious workers and organizations or industries in economic trouble (study 4).

Risk of injury associated to precarious employment (RQ5)

Precarious employment, as defined though formative work in study 1, will be the independent variable of interest in a multivariate analysis with occupational injury as the outcome. It is well known that the risk of occupational injuries decreases with tenure at any given job. It is unlikely that there is an accumulation of risk or latency in the precarious employment–occupational injuries relationship. We will therefore measure risk and outcome at the same point in time, i.e. precarious employment and injury in the same year. We will also explore the interaction effects of age and tenure/experience. Analysis will be adjusted for socio-demographic variables. A longitudinal dimension will be introduced by analyzing the changes in risks over the time of the study period (2003-2015). Due to the large differences in risk of injury based on occupation, sector and industry, we will perform stratified analysis based on these variables. Apart from this, we will provide the population attributable fraction as part of our results.

The outcome will be stratified based on severity of injury and differences in risk of injury severity between precarious and non-precarious employees will be explored.

Risk of injury associated to key business indicators (RQ6)

A cohort of all Swedish companies will be created. The outcome will be defined as occupational injury per full-time employee and calculated for each year for each individual company. We will calculate short-term (1 year) and long-term (5-year) trajectories in key business indicators for each company and use these as the main independent variables of interest in a multivariate regression analysis. Stratified analysis will be carried out based on company size, industry/sector. As in RQ5, the outcome will be stratified based on severity of injury and the population attributable fraction will be calculated.

**Preliminary findings**

In this protocol we present preliminary findings based on linkage of different data sources for the working population aged 18-65 years, during the year 2013. The total number of occupational injuries reported only in AFA, only in ISA as well as the overlap (presence in both registers) are shown in Table 3. Linkage between AFA and ISA registers for this preliminary analysis was conducted on id-number (de-identified) and injury date, on a +/- 7 days' range. There was approximately a 36% overlap between the two data sources.

**Table 3.** Number of occupational accidents reported to either ISA, AFA or both (overlap)*, together with presence in the National Patient Register (in- and out-patient), for the year 2013 in Sweden.

| | All reported injuries | | Total NPR | | In-patient | | Out-patient | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| ISA only | 49 356 | 47,6 | 5 343 | 10,8 | 368 | 0,7 | 4 975 | 10,1 |
| AFA only | 17 095 | 16,5 | 4 458 | 26,1 | 371 | 2,2 | 4 087 | 23,9 |
| ISA and AFA | 37 138 | 35,9 | 10 131 | 27,3 | 1 119 | 3,0 | 9 012 | 24,3 |
| Total | 103 589 | 100,0 | 19 932 | 19,2 | 1 858 | 1,8 | 18 074 | 17,4 |

**Linkage of datasets conducted on id-number (de-identified) and injury date in a +/-7 days' range.*
*NPR= National Patient Register*

**DISCUSSION**

In this project we aim at operationalizing precarious employment in Swedish labor market registers and use this definition to conduct several large, register-based prospective etiological studies, designed to measure effect sizes and interactions of the relation between precarious employment, business performance and occupational injuries. Taking advantage of two separate and comprehensive reporting systems for occupational injuries in Sweden we will also estimate under-reporting of occupational injuries and the factors which are related to this issue. In this protocol, we present preliminary results for the overlapping of occupational injuries for the year 2013.

**Strengths and limitations**

We believe that the major strength of our project will arise from the results from the first study, i.e. the operationalization of precarious employment. This, together with the identification of key

business indicators of relevance for the association between precariousness and occupational injuries can be considered as a valuable start point for future research investigating these factors.

By using the unique Swedish personal and organisation identification numbers from ISA and LISA we are able to link both individuals and companies to each other and to the injury databases. The use of high quality, nationwide register data covering the total working population provides power to the study and virtually zero loss to follow-up. A wide range of variables from different sources, together with the long follow-up period will enable us to adjust for confounders and apply longitudinal designs, mitigating several sources of bias. Information on sickness absence and hospitalization allows us to characterize our outcome in terms of severity, further adding quality aspects to outcome measurement.

However, some limitations and methodological challenges should be addressed.

Occupational injury definition:

The system of self-reporting and somewhat ambiguous definition of occupational injury introduces the risk of misclassification between occupational injury and disease. This problem is likely to be most serious in the case of musculoskeletal disorders (MSDs) where repeated over-exertion leading to an MSD could be reported as both an occupational injury and occupational disease. For women, over-exertion injuries (physical over-exertion such as during heavy lifting and carrying, jerks, slips) constituted the second most common cause/type of occupational injury with at least one day of sickness absence in Sweden. [26] For men it was the third most common cause. If the misclassification was random and steady over time this would pose a lesser problem, but we have reason to believe that the preference to choose between reporting MSDs as injuries or diseases might be biased by preconceptions about chances of getting a claim granted in either category and that this changes over time as a consequence of regulatory changes.

Additionally, there is risk of including "non-occupational" injuries while investigating reports rather than approved claims. The rationale for not limiting the reports to approved injuries is that the rules for receiving compensation have been tightened over the last decade and we believe that on the group level, there is more consistency over time in employees' notion of what qualifies as an occupational injury than in the assessment by the social insurance agency. In personal communication with civil servants at the Swedish Work Environment Authority, the presence of non-occupational injuries has been deemed "an issue in the margin".

Finally, although the occurrence of traffic-related injuries is increasing in some countries, [27] we decided to exclude those from our study. Injuries that occurred during transit to/from work may be covered by car insurances and may therefore not appear in the occupational injury registers.

Injury severity:

In Sweden, sickness absence is reimbursed by the Swedish Social Insurance Agency starting on day 15. The near universal coverage of the regular sickness insurance scheme and the additional coverage specifically for injuries makes us rather confident that we will be able to identify most serious injuries occurring in the formal labour market. The other severity measure obtained through hospital records only covers injuries, poisoning and some other consequences of external causes (S and T chapters in ICD-10). Thereby, we will not identify major injury categories such as acute lumbago (M45.3).

Whether we characterize severity in terms of days of hospitalization or reimbursed days lost of work, we have a rather large difference between mild and severe cases, losing the broad spectrum of less severe injuries while severe cases can be classified in more detail.

Precarious employees:

Although we have not yet operationalized precarious employment in registers, we foresee some constraints. Among other issues, type of contract (permanent/temporary) is not registered as such

and will be constructed by proxy variables obtained from LISA, such as number of employers and number of sources of income. EU citizens stationed in Sweden and informal workers are not covered in this study, groups that are of special interest in research on precarious employment. This is a major limitation, but the constraints in data do not allow us to study these two categories of potentially precarious workers.

Precarious employees are less likely to be covered by collective agreements and therefore the issue will be greatest here. We also hypothesise that they are less likely to report injuries. This will affect both our analysis of under-reporting using capture-recapture, and also the estimates for the association between precarious employment and the risk of occupational injuries.

Key business indicators:

Previous studies have found that as the financial condition of a firm deteriorates, it is likely to adopt policies that will lead to an increase in safety violations, accident rate, and in environmental hazards [18] and that when revenue increases the opposite would occur. [19] The opposite might however be true as well. As revenue falls, the work tempo might shift downwards temporarily and the short-term effects on injuries might be positive. Lay-offs of those with least tenure may also leave a larger proportion of experienced workers which could lead to fewer injuries. Mirroring this; as revenue increases in a company, new employees come in who are at higher risk. Disentangling these effects and counter effects of changes in key business indicators will be a major challenge and will require important formative work on causal pathways and the construction of logic models prior to analysis. Due to the lack of prior research in this area, an exploratory approach using data-mining or machine learning algorithms will also be applied to discover risk factors and pathways which we cannot foresee at the moment.

Working hours:

When calculating risk of occupational injuries, a measure of working hours is needed as denominator in order to make just comparisons. Lacking data on individual working hours in this project we have to rely on proxy variables to make estimations. Due to collective bargaining the wage structure in Sweden is rather homogenous, especially for blue collar workers and white collar workers with low skills. We are currently exploring the feasibility of using wage in combination with occupational code and industry code as well as the public registers on median salaries in certain occupations (survey-based information) to create a proxy for fulltime employment based on the deviation from the median wage.

Formal/informal work:

As this study partly focuses on precarious employment, we need to spell out that this study is only investigating the formal economy. Not including people working in the informal sector completely or partly will be one of our major limitations. According to the 2015 European Working Conditions Survey (EWCS), the prevalence of informal employment for Sweden is estimated to be 5%, lying below the average for the European union (10%). [28] Those who are formally employed but receive part of their salary “under the table” will be especially at high risk of being misclassified. Also, foreign citizens working in Sweden but whose employer is registered in another country will be absent in this study. We know that these workers are very common in construction and logistics, two industries with high risk of injury.

Under-reporting:

Capture-recapture is a method that has been widely used in epidemiology to estimate unknown size of populations. Methodological issues may appear from dependence among data sources being used to obtain estimates. [25] When it comes to occupational diseases, AFA requires that a report is made first to ISA, therefore one would expect a high level of dependency and that AFA would be completely nested in ISA. For occupational injuries, this is not the case and there is a large proportion of injuries that are only reported to AFA. This said, the detected dependency may result

in an overestimation of the true population size, and we must therefore treat our estimations cautiously.

Also, the AFA insurance scheme is not as comprehensive as ISA's. The ISA register covers 100% of the employees and self-employed while the AFA register covers 100% of public sector employees and all employees within the private sector who have signed a collective agreement. However, collective agreements are less common in small companies and certain industries such as hospitality where 45% of the companies have collective agreements. This will limit our ability to make good estimates in some labour market sectors.

Finally, under-reporting of occupational injuries may be higher among precarious workers, and conversely, these workers may have a higher rate of injuries compared to non-precarious workers. To be able to observe differences in the under-reporting for precarious workers compared to non-precarious, we will conduct stratified analyses.

## DISSEMINATION

The project is presently planned to result in a series of papers published in international peer-reviewed scientific journals, at least one PhD thesis and a report in Swedish aimed at relevant stakeholders including governmental agencies, policy-makers and social partners (employers and trade unions). Due to the richness of the data obtained and the multiple scientific approaches we anticipate that the project will result also in further publications than those outlined in this protocol, including future collaborations. Results of public interest will be formatted as press releases and sent to Swedish and international media with support from the University press services.

## CONCLUSION AND POLICY IMPLICATIONS

We believe that this project will address some of the most pressing issues related to occupational injury surveillance and research. Despite some limitations, the inclusion of different studies within this project, using several methodologies, together with the statistical and high quality of the data will allow us to explore trends and risks in occupational injuries in Sweden from many perspectives.

The richness of our data will allow us to conduct several specialized sub studies in the future which have not been outlined here, and we would be happy to receive suggestions for further studies and invitations to collaborate.

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**Author Contributions**

CO has drafted previous versions and the final version of the manuscript. TB is the principal investigator of the project. BK, GJ, BB, KK, TH, MA, LD and DW participate in the project and have contributed to the design of the project and its studies. All authors have read and approved of the final version of the manuscript.

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**Competing interests**

None declared.

**Availability of data and material**

Data sharing not possible according to Swedish regulations.

**Ethics approval and consent to participate**

Ethical permission for the study for the project duration was granted by the Regional Ethics Committee, Stockholm (Dnr 2016/2325-31 and 2017/2173-32).

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