Chapter 2

Accidents at work in Italy: an empirical analysis at the provincial level

Abstract

The aim of the paper is twofold. First, this work investigates workplace accidents in Italy at the provincial (NUTS 3) level by accounting for business cycle, productive system, workforce demography, and institutional variables. Second, we test the underreporting hypothesis, examining the case that rates of minor injury can be explained by both working conditions and the willingness of workers to report injuries.

Among our main findings, the analysis shows that, at Italian provincial level, business cycle (unemployment, added value, and rate of change of investment/GDP) strongly affect the pattern of workplace accident. Moreover, the results show statistically significant relations between productive system (firms' size, territorial sectoral structure, workforce' skill composition), workforce demography characteristics (gender and age), institutional variables (non-regular employed and compliance to the legal norm index) and the accident phenomenon alternatively defined with different indicators.

Therefore, the analysis seemingly confirms the complexity of the phenomenon, which should also be considered for possible policy interventions. In addition, our analysis suggests that, especially in economic downturns, selective public policies geared toward supporting occupational safety and health investment should be a complementary tool to conventional policy options (rule enforcement and training). Finally, the results also indicate that policies should focus on the most vulnerable workforce, such as low-paid, low-skilled, precarious, and young workers, and on their fair reporting of injuries to avoid inconsistent reporting over the business cycle.

1. Introduction

Safety in the workplace is a fundamental aspect of workers' well-being. For this reason, attention to this issue has been strongly refocused in recent years at the political, economic, and social levels, resulting in a wide and interdisciplinary literature (Galizzi et al., 2023; De Sario et al. 2021; Pascucci and Delogu, 2020; Sclip, 2019; Delogu, 2018; Alessandrini et al. 2017; Tullini, 2017; Conti, 2016).

The relevance and complexity of the phenomenon (Cornelissen et al., 2017; Fabiano et al., 2004; Laflamme, 1990) has led to the need for more in-depth investigation of the determinants of the occupational injury event. Moreover, a growing strand of literature (Leombruni et al., 2019; Palali and van Ours, 2017; Boone et al., 2011; Boone and van Ours, 2006; Leigh et al., 2004) emphasizes the possibility of different reporting behaviour between severe and minor injuries and warns that observed workplace injuries could be related to reporting behaviour rather than merely to workplace health and safety levels.

In this vein, this work focuses on two main issues. First, we analyse occupational accident rate (OAR) in Italy at the provincial level and following the strand of international literature that delineates accidents as a complex and multidimensional phenomenon (Cornelissen et al., 2017; Fabiano et al., 2004; Laflamme, 1990) we account for business cycle, productive system, workforce demography and institutional variables. Second, we test the underreporting hypothesis by considering alternative measures of work injury rates. In fact, underreported injuries do not result in official account. In our perspective, this could lead to biased dependent variable and, consequently, to biased estimates. Therefore, following Leombruni et al. (2019), Boone et al., 2011, and Boone van Ours (2006), since underreporting is inversely related to the severity of the injuries, we gradually increase the severity of our dependent variables by focusing first on minor accident rate, and then on severe and finally on severe plus fatal accident rate.

To this purpose, we use Inail (National Institute for Insurance against Accidents at Work) and Istat (National Institute of Statistics) data for the period 2011-2019 to implement different econometric estimation techniques (pooled OLS model, fixed effects model and random effects model), which allows us to better consider local and temporal specificities.

Moreover, we consider alternative measurements of the accident rates according to the severity of the workplace accidents to minimize the magnitude of a potential underreporting bias, looking at the change in the magnitude of estimate coefficients.

As will be seen in the course of the work, in most of the estimates, the results show statistically significant relationships between some local economic and social context variables (unemployment,

added value, investment/GDP, firm's size, sector of activity, demography of the workforce, and index of rule of law) and the accident phenomenon alternatively defined with different indicators. Therefore, the analysis seemingly confirms the relevance of the local dimension, which should also be considered for possible policy interventions. In addition, the analysis confirms the underreporting theory and the need for action to counter it, particularly about the most vulnerable labour categories.

This work is structured as follows. After introducing a literature review on the topic in Section 2, Section 3 describes the data and variables used in the analysis. Section 4 and 5 describe the econometric methodology and the estimation results, respectively. Finally, Section 6 contains concluding remarks.

2. Accidents at work: a literature review

Numerous studies have analysed the determinants of workplace accidents and occupational diseases, contributing to a literature that nowadays seems to suggest that OSH is a combination of determinants ranging from individual and workplace-related factors to socioeconomic and institutional characteristics (Cornelissen et al., 2017; Fabiano et al., 2004; Laflamme, 1990). From this perspective, the occurrence of a workplace accident results from the interaction of a multitude of elements that increase or decrease the probability of the event, whose understanding is crucial for both firms in the prevention phase and policy-makers in the design and implementation phase of a policy (Micheli et al., 2018).

A broad strand of literature focuses on the impact of the business cycle on accident frequency. It has been shown that accident rates increase significantly during upturns and decrease during recessions (de la Fuente et al., 2014; Asfaw, 2011; Ruhm, 2000) at least in the short term (Giraudo et al., 2019). Specifically, in the upturn (downturn) phases this can be attributed to the increase (decrease) in the extensive margin of the labour force (Anyfantis et al., 2018, Davies et al., 2009; Lindroos et al., 2008; Folkard and Lombardi, 2006; Dembe et al., 2005; Lilley et al., 2002; Robinson, 1988). In addition, de La Fuente et al. (2014) show that economic recession seems to exert a sort of "natural selection" in the labour market where only the most fit tend to remain employed, with a far lower probability of sustaining a workplace injury.

However, in recessions, the decrease in work injuries may not reflect healthier and safer conditions for workers, as shown by some authors (Giraudo et al., 2019; Leombruni et al., 2019; Robinson, 1988) who find a negative relationship between unemployment and OSH conditions. Indeed, the

crisis could become an excuse for the failure to meet labour standards and could lead to greater pressure on workers to accept lower standards for working conditions (Anyfantis et al., 2018).

The analysis of the relationship between accidents and the business cycle becomes even more complex if we also consider the possible effects of unemployment on workers' reporting behaviour. Boone and van Ours (2006) analyse the cyclical fluctuation of occupational accidents by distinguishing between fatal and nonfatal accidents in 16 OECD countries, showing that fatal accidents, in contrast to nonfatal accidents, do not exhibit a pro-cyclical pattern. The authors then test the underreporting theory, according to which this difference in cyclicality is due to workers' (non)reporting behaviour rather than to elements strictly related to occupational safety. In fact, while fatal accidents are always reported, nonfatal accidents do not always emerge. Indeed, reporting an accident could affect a worker's reputation by increasing the likelihood of being fired (Boone et al., 2011), which, in the presence of high unemployment rates, leads to significant losses due to the difficulty of reemployment and re-entering the labour market. This difference in reporting behaviour between serious and minor injuries has also been confirmed by Leombruni et al. (2019), who suggest that workers that entry in the labour market in adverse macroeconomic conditions have a weak bargaining position that may lead them to underreport injuries.

The cyclical fluctuations in reporting behaviour could also influence the entrepreneurs' OSH investment decisions: in a downturn phase, when firing rates arise, workers may underreport workplace accidents and the firms under-invest in workplace safety; in an expansion phase workers may over-report workplace accidents and the firms over-invest in OSH (Boone et al., 2011).This evidence becomes particularly fuzzy since fixed investment variable appears negatively related to accident rate in many studies (Asfaw et al., 2011; Davies et al., 2009; Boone and van Ours, 2006; Ussif, 2004; Brooker et al., 1997).

Against this background, the relationship between the business cycle and occupational injury rate trends is rather puzzling, because several factors act in opposite directions, with the final effect depending on the prevailing factor.

A further strand of literature shows that the production system characteristics influence the frequency of workplace accidents. The size composition of firms in the country is considered a variable that can have an impact on OSH levels: the higher is the number of micro enterprises the greater is the risk of the occurrence of the occupational accident phenomenon (Micheli et al., 2018; Walters et al., 2018; Nordlöf et al., 2017; Sinclair et al., 2013; Hasle et al., 2012; Hasle and Limborg, 2006; Champoux and Brun, 2003; Dorman, 2000). Firm size also appears to be relevant to reporting

behaviour, with workers employed in larger firms more likely to report work-related injuries than those employed in their smaller counterparts (Boone et al., 2011; Boone and van Ours, 2006; Fabiano et al. 2004; Morse et al., 2004; Oleinick et al., 1995).

Furthermore, there is a broad consensus that the sector of economic activity plays a decisive role on occupational accident risk (Lenaerts et al., 2020; Khanzode et al., 2011; Haslam et al., 2005; Maiti et al., 2004, 2001; Maiti and Bhattacherjee, 1999; Leigh, 1989; Walters and Wadsworth, 2016; Parent-Thirion et al. 2012). Intersectoral differences are crucial in terms of occupational structure, which places certain groups in a particularly vulnerable position. Indeed, sectors dominated by *low-educated blue-collar* occupations, such as mining, construction, agriculture, industry, and transport, typically have less safe physical environments; in contrast, sectors dominated by *white-collar* occupations, such as financial services, education, and public administration, benefit from safer physical environments (Lenaerts et al., 2020)[1]. Finally, sectors of activity are relevant since mechanisms through which the business cycle influences the incidence of occupational injuries may differ from one sector to another (Giraudo et al., 2019).

A substantial part of the literature also highlights the relationship between workers' demography (gender and age) and occupational safety and health condition. There is widespread consensus that industries with a high risk of injury occurrence, such as construction, transport, industry, and agriculture remain highly male-dominated (Biswas et al., 2021; Parent-Thirion et al., 2016; Eng et al., 2011); on the other hand, women tend to be employed in occupations and economic activities (e.g., services) with greater exposure to work-related psychosocial risks (Campos-Serna et al., 2013). The age of the worker is also considered a variable influencing exposure to injury risk. Without neglecting the problem of managing the aging of the working class, younger workers are often in the most vulnerable status with respect to OSH (Hanvold et al., 2019; Pouliakas and Theodossiou, 2013; Blanch et al., 2009; Swaen et al., 2004). In fact, a large percentage of young workers are employed (i) in more OSH-hazardous industries, such as health care, hospitality, agriculture, and construction, (ii) by smaller organizations (iii) and workplaces where employees are precarious or temporary[2], all characteristics that make them at greater risk of workplace accidents (Tucker et al.,

[1] Thus, while sectors dominated by the so-called *white-collar* workers, with a higher level of education, are subject to OSH risks that are more related to psychological factors (such as stress and anxiety), the so-called *blue-collar* workers, with lower level of education, are subject to a higher risk of physical injuries (Lenaerts et al., 2020; European Commission, 2008; Dorman, 2000).

[2] A large strand of literature focuses on the impact of precarious/temporary employment and OSH. In particular, temporary contracts are associated with a higher frequency of accidents (Morassaei et al., 2013; Lopez et al., 2008; Virtanen et al., 2005) and, for some authors, even their greater severity (Sánchez et al., 2011; Virtanen et al. 2005; Fabiano et al., 2004, 2008; Blanche et al., 2009; Benavides et al., 2006; Dupré, 2001) due to lack of experience,

2014). In addition, Leombruni et al., 2019, show that, during a recession, the likelihood of a young worker starting his or her career in informal (low-paid) work increases significantly. This shift to more hazardous jobs does not necessarily result in the creation of new risks, but a redistribution of hazardous jobs to young workers that implies that injuries will be more likely to occur in the early stages of the career, with possible negative effects over a longer period (Leombruni et al., 2019).

Finally, a further category of possible determinants of accident frequency is the institutional characteristics. In particular, the idea is that the lower the compliance with existing OSH regulations the higher the risk of occurrence of occupational accidents (Lindroos et al., 2008). Indeed, it is well known in the literature that the propensity for OSH regulatory compliance, as well as the adoption of good organisational and managerial practices, ensure better performance in terms of workplace safety (Mohammadfam et al., 2017; Walters and Wadsworth, 2016; Antonsson et al., 2002)[3]. In addition, there exist a negative relationship between regulatory compliance and the shadow economy[4] (Schneider and Buehn, 2012). The size of the shadow economy is a significant problem for most countries, albeit to varying degrees, in both developing and advanced economies (Orsi et al., 2014). In Italy, in particular, estimates reveal that the size of the informal economy is among the highest within the "old" EU[5] (Schneider and Asllani, 2022). These stylized facts are particularly

insufficient specific knowledge and inadequate training. Picchio and Van Ours (2017) show that workers with fixed-term contracts, when subjected to a work injury, were more likely to suffer serious injuries than permanent workers but found that the effect could be driven by the under-reporting bias of minor injuries. Giraudo et al. (2016) find that individuals with precarious careers experience a higher risk of injury. However, this effect should not be read as a causal effect: on the one hand, this effect may depend upon the fact they have lower average duration jobs and, therefore, less specific experience on average; moreover, as they shift more often from one economic sector to another, they benefit from a lower protective effect of the human capital accumulated in previous jobs; on the other hand, there may also be an opposite causal issue: a possible selection problem exists, related to the fact that less skilled individuals may have at the same time a higher probability of injury and a lower probability of finding stable employment.

[3] Among institutional determinants, the adoption of appropriate organisational models also plays an important role (Ipsen et al., 2015; Parent-Thirion et al., 2012; Kogi, 2002; Vassie et al., 2000; Shannon et al., 1996). Organised work, in fact, operates at different levels to make workplaces safer (Walters et al., 2005) since the characteristics and choices regarding the organisation of work, both at a technical and human level, determine the general context in which tasks will be performed (Laflamme, 1990). In particular, certain aspects of process organisation, working methods and the organisation of the work itself - such as working hours or soft tools such as task rotation, teamwork and worker involvement - are elements that determine the physical environment in which the task is carried out, and represent a managerial responsibility that decisively impacts the level of workers' exposure to the risk of injury (Irastorza et al., 2016; Parent-Thirion et al., 2012).

[4] As in the relevant literature on the subject (Schneider and Asllani, 2022; Simona Talani, 2019; Schneider, 2010; Schneider and Enste, 2000) we will use interchangeably the terms shadow economy, informal economy, underground economy, and hidden economy.

[5] In Italy, the main driving causes of the shadow economy are the number of self-employed, indirect taxes, unemployment rate, and personal income tax (Schneider and Asllani, 2022). In general, unemployment is a major determinant of the growth of the shadow economy (Deléchat and Medina, 2021; Wu and Schneider, 2021; Schneider, 2010): the higher (lower) the unemployment, the higher (lower) the incentive to work in the shadow economy, ceteris paribus.

worrisome considering that working condition protections in the informal economy are completely absent (Orsi et al., 2014). Moreover, lower regulatory compliance (thus a larger size of the shadow economy) could correspond to a lower propensity to comply with the duty to report injuries when an accident occurs.

3. Data and Variables

The database is built using Inail's microdata on accidents at work over the time-span 2010-2019. After aggregating the tables provided by the Institute into a single provincial database, we calculate different Occupational accidents rates which represent the dependent variables alternatively used in this study to consider the different consequences of the accident phenomenon on workers, which, in this work, constitute the dependent variables alternatively used in the econometric model. Specifically, we use three different dependent variables, namely (i) the OAR of minor accidents, i.e., involving up to 30 days of absence from work, (ii) the OAR of severe accidents, i.e., accidents involving more than 30 days of absence from work, permanent disabilities, and (iii) the OAR of severe and fatal accidents, i.e., accidents involving more than 30 days of absence from work, permanent disabilities, and fatal accidents. These indicators are observed on an annual basis and are measured in relation to the number of employees, measured as full-time equivalent (FTE)

Table 1 provides an overview of the dependent variables included in the analysis, giving a brief description of each one and illustrating the source of the data and the unit of measurement used.

Table 1. Dependent variables description.

Variable	Description	Source	Unit of measurement
OAR minor	Number of minor accidents at work out of number of full time equivalent	Inail	Ratio*100,000
OAR severe	Number of severe accidents at work out of number of full time equivalent	Inail	Ratio*100,000
OAR severe & fatal	Number of severe and fatal accidents at work out of the number of full time equivalent	Inail	Ratio*100,000

Data needed to measure the covariates of interest at the provincial scale for the period 2011-2019[6] are selected from ISTAT. The dataset obtained is expanded by including additional variables constructed from ISTAT data on Fair and Sustainable Welfare (BES).

The independent variables are classified into four groups. The first group of variable illustrates aspects related to the business cycle. Following the relevant literature, we focus on the unemployment rate (Leombruni et al., 2019; Anyfantis et al., 2018; Boone et al., 2011; Boone and van Ours, 2006), added value (de la Fuente et al., 2014; Asfaw et al., 2011), and investments over GDP (Takala, 2019; Asfaw et al., 2011; Davies et al., 2009; Sari et al., 2004; Brooker et al., 1997; Blank et al., 1996; Asogwa, 1988; Laflamme and Cloutier, 1988). Unemployment is expressed as the unemployment rate for the age group of 15 years and over. To measure the level of production activity we consider the variable "Added value", which allows measurement of the growth of the economic system in terms of new goods and services available for final use[7]. To account for the impact on occupational injuries of investments, we consider the rate of change of investments/GDP at regional level.

The second group of variable includes information on the productive system characteristics. With reference to productive system characteristics, as widely highlighted in the literature, firm size is considered a relevant variable able to exert a significant impact on the level of occupational risk (Micheli et al., 2018; Nordlöf et al., 2017; Fabiano et al., 2004; Morse et al., 2004; Antonsson et al., 2002; Leigh, 1989; Oleinick et al., 1995). We define "Micro" as the percentage of workers employed in micro enterprises ($\leq$ 10 FTE) out of total employees, and "SME" the percentage of workers employed in small and medium enterprises (11 $\leq$ FTE $\leq$ 249) out of the total employees. Given the relevance of the sectoral perspective in the prediction of the accident phenomenon, particularly for the study of risks related to the physical environment (Khanzode et al., 2011; Haslam et al., 2005; Maiti et al., 2001, 2004; Maiti and Bhattacherjee, 1999; Leigh et al., 1989), We introduce in the analysis the variable "Employment risk" measured as the percentage of employees in highly-risk sectors (i.e., Mining, Manufacturing, Construction and Transport) out of total employees, sectors dominated by *blue-collar* occupations (Lenaerts et al., 2020). Moreover, following the skill-effect hypothesis, according to which workers with more education are at lower risk of physical environment-related injuries (Walters and Wadsworth, 2016; Parent-Thirion et al. 2012; Khanzode

[6] The reason for not using the year 2010 for the analysis is due to the non-availability of data for that year for all control variables.

[7] https://www.istat.it/it/metodi-e-strumenti/glossario

et al., 2011; Haslam et al., 2005), the relevance to the spread of secondary education is considered, measured by reference to the number of individuals aged 15-64 who have completed at least upper secondary school (qualification no less than Isced[8]).

The third category of possible determinants of accident frequency is the demography of the workforce. We consider the covariate "Women" representing the percentage of female employees out of the total of employees. We also consider the variable "Youth" representing the rate of youth employment (15-29 years old).

The last category of determinants of occupational accident rate is institutional characteristics of the economic system. Considering the relevance of the quality of institutions, with particular reference to compliance with regulatory provisions (Micheli et al., 2018; Irastorza et al., 2016; Pedersen et al. 2012; Lindroos et al., 2008), the degree of legality and the level of economic well-being in the territory are considered. Since there exist a negative relation between compliance to the legal regulation and the size of the shadow economy (Schneider and Buehn, 2012), as proxy for compliance with the duty to report injuries when an accident occurs (reporting behaviour) we consider irregularly employed at regional level. ISTAT estimates the employed as nonregular when work positions are carried out without compliance with the applicable tax-contribution regulations. Finally, as a proxy for OSH compliance, we use the covariate "Rule of law"[9], which summarises data on crime against persons or property, magistrate productivity, trial times, tax evasion and shadow economy[10]; this indicator ranges from 0 to 1, with higher (lower) values for better (worst) performer provinces. Table 2 presents an overview of the independent variables included in the analysis, providing, for each of them, a brief description and illustrating the source of the data and the unit of measurement used.

Table 2. Independent variable

Variables	Description	Source	Unit of measurement
Unemployment	Percentage ratio of the unemployed in the age group of 15 years and over to the total employed and unemployed (labour force) in the same age group	Istat	Rate
Added value	Value of production minus the value of intermediate costs per person in employment.	Istat	Ratio

[8] International Classification of Education

[9] Rule of law is one of the five dimensions of the Institutional Quality Index (IQI - measures of corruption, governance, regulation, law enforcement and social participation). The IQI items cover the main dimensions of institutional quality and refers to Italian provinces for the entire 2004-2019 period. Full technical details on these dimensions can be found in Nifo and Vecchione (2014)

[10] https://drive.google.com/file/d/1uHsNJaRDlKighq1KZRoXdlgP7Cg5MCzZ/view

Investments/GDP	Gross fixed capital formation as a percentage of gross domestic product (regional)	Istat	Rate
Secondary Education	Percentage of 25-64 year olds who have completed at least secondary school (qualification not less than Isced 3) out of the total 25-64 year olds	Istat	Percentage
Micro	Percentage of employees in micro enterprises (≤10 FTE) out of the total employees	Istat	Percentage
SME	Percentage of employees in small and medium enterprises (11 ≤ FTE ≤ 249) out of the total employees	Istat	Percentage
Employment Risk	Percentage of employees in highly-risk sectors (i.e., Mining, Manufacturing, Construction and Transport) out of the total persons in employment	Istat	Percentage
Women	Percentage of women in employment out of the total employment	Istat	Percentage
Youth	Percentage ratio of employed people in the 15-29 age group to the total resident population in the same age group	Istat	Rate
Non regular employed	Percentage of workers performing jobs without complying with tax-contribution regulations per total number of employees (regional)	Istat	Percentage
Rule of law	Perception concerning law enforcement both in terms of contract fulfilment, property rights, police forces, activities of the magistracy and crime levels	IQI	Index

Table 3 presents the main descriptive statistics for the dependent variables. The OAR minor (involving up to 30 days of absence from work) ranges from a minimum of 481.58 per 100,000 of employees (for Caserta in 2019) to maximum of approximately 3541.98 per 100,000 of employees (for Rimini in 2010). On average, the index takes a value of 1416.19.

The OAR of severe accidents varies from a minimum of 278.29 (for Milano in 2019) to a maximum of approximately 2801.85 severe accidents per 100,000 employees (for Sud Sardegna in 2016). On average, the index takes a value of 807.39.

The OAR involving severe & fatal accidents ranges from a minimum of 279.31 (for Milano in 2019) to maximum of approximately 2827.97 per 100,000 employees (for Sud Sardegna 2019). On average, the index takes a value of 811.97.

Table 3. A brief description of the dependent variables.

Variables	Observations	Mean	Std. Dev.	Min	Max
OAR minor	964	1416.189	481.63	481.575	3541.975

OAR severe	964	807.398	252.143	278.286	2801.847
OAR severe & fatal	964	811.97	253.242	279.313	2827.971

Table 4 presents the main descriptive statistics for the independent variables.

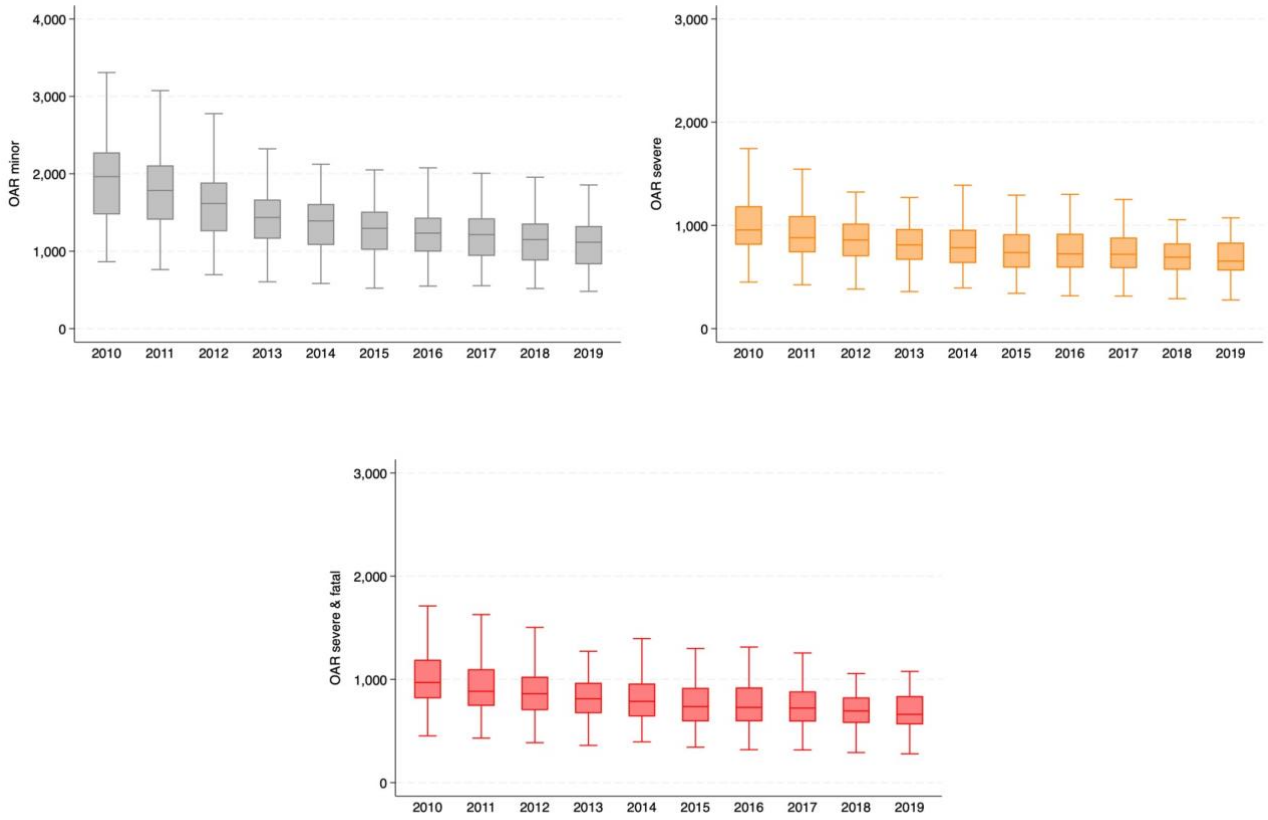
Table 4. Independent variables description.

Variables	Obs	Mean	Std. Dev.	Min	Max
Unemployment	964	11.154	5.575	2.694	31.456
Added value	964	56.88	7.298	42.242	80.359
Investment/GDP	964	0.722	0.454	0.023	1.841
Secondary Education	964	57.571	7.999	0	75.7
Micro	964	54.927	11.291	23.091	79.52
SME	964	32.548	5.464	19.872	47.171
Employment Risk	964	40.939	9.59	17.182	61.067
Women	964	41.013	3.979	26.528	47.532
Youth	964	63.116	14.25	25.363	85.347
Non regular employed	964	13.111	4.235	7.4	23.2
Rule of law	964	0.571	0.236	0	1

Figure 1 illustrates the time trend of the dependent variables. In particular, a slight decreasing trend of the median values can be observed for minor accidents, while for severe and severe & fatal accidents the median trend is rather flat.

Figure 1. A temporal representation of dependent variables.

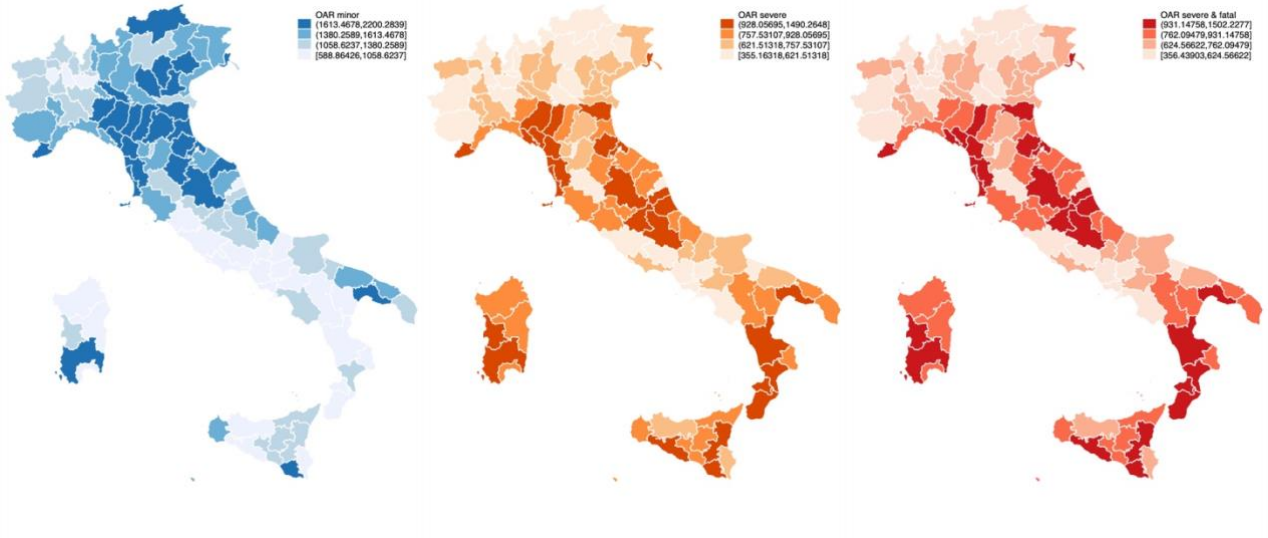
In order: OAR minor, OAR severe, and OAR severe & fatal



Finally, Figure 2 shows the spatial distribution of the three dependent variables included in the analysis (average value 2010-2019, On average, higher values of OAR minor are observed in some central-northern provinces and north-eastern provinces; on the other hand, the average OAR severe and severe & fatal seems to take higher values in central, central-southern provinces, and in the Island provinces.

Figure 2. A geographical representation of dependent variables.

In order: OAR minor, OAR severe, and OAR severe & fatal



Source: based on Inail data.

Note: The colours in Figure become darker according to the following scale:

i) OAR minor: [588.86-1,058.62]; (1,058.62-1,380.26]; (1,380.26-1,613.47]; (1,613.47; 2,200.28]

ii) OAR severe: [355.16-621.51]; (621.51-757.53]; (757.53;928.06]; (928.06-1490.26]

iii) OAR severe plus fatal: [356.44-624.57]; (624.57-762.09]; (726.09-931.15]; (931.15-1,502.23]

Such different evidence in terms of geographical occurrence between minor and severe & fatal OAR could be explained both in terms of different OSH level, and in terms of reporting behaviour, since it is possible to observed different reporting behaviour for minor and more severe accidents, being the latter harder to hide from the injured worker (Leombruni et al., 2019; Tucker et al., 2014; Alamgir et al., 2006; Shannon and Lowe, 2002). Along these lines, our analysis focuses on occupational injuries while accounting the underreporting hypothesis.

4. Econometric Methodology

This section describes the empirical methodology. We focus on two mains research questions. First, we investigate workplace accidents in Italy at the provincial level by accounting for business cycle, productive system, workforce demography and institutional variables following the strand of international literature that delineates accidents as a complex and multidimensional phenomenon (Cornelissen et al., 2017; Fabiano et al., 2004; Laflamme, 1990)

Second, following Leombruni et al. (2019), Boone et al., (2011), and Boone van Ours (2006), we test if reporting behaviour differs between severe and minor workplace accidents by considering alternative measurements of the occupational accident rates.

To analyses at the provincial level the occupational injury phenomenon in Italy we use an OLS regression model with longitudinal data, which assumes the following log-log specification:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 DE_{it} + \beta_4 CI_{it} + T_t + FE_i + \varepsilon_{it} \qquad (1)$$

where subscripts i and t represent the provincial scale of the Italian context and the temporal dimension, respectively, with annual observation frequency. Since underreporting is inversely related to the severity of the injuries (Leombruni et al., 2019; Tucker et al., 2014; Alamgir et al., 2006; Shannon and Lowe, 2002) as dependent variable Y, we initially use the OAR minor; then, at a later stage, we extend the analysis to the OAR of the severe accidents, and finally to the OAR of severe plus fatal accidents. The key idea is that, if underreporting operates, unreported injuries (particularly less serious ones) are not included in official accounts, which could lead to undercounting of injuries and consequently to biased estimated relationships (Palali and van Ours, 2017). Therefore, to try minimizing the extent of the underreporting bias, looking at the change in the magnitude of estimate coefficients among estimates, we investigate, whether reporting behaviour of workplace accidents varies between minor and more severe workplace accidents.

About the covariates used in all regression models, X is a vector of business cycle controls (unemployment rate, added value per employees, rate of change investments/GDP), Z is a vector of the productive system characteristics of the provinces considered (secondary education, and number of employees in both micro and small-medium-sized enterprises over the total of employees, employment risk); DE is a vector containing variable representing the demography of the workforce (percentage of female employees and youth employment rate??) and CI is the compliance index territorial variable (nonregular employment, and rule of law index). Finally, T and FE are the temporal (annual) and spatial (provincial) fixed effects, respectively, ε is the error term that tends to be i.i.d. $(0, \sigma^2)$. To choose between fixed and random effects estimation the Hausman's test (1978) is used.

Summarizing, adopting different estimation strategy that considers fixed and random effects leads to different estimates of the set of parameters associated with the independent variables. This makes it possible to gain a deeper understanding of the factors most correlated with accident incidence. At a later stage, based on the same covariates, the study of the phenomenon is deepened by using the other dependent variables shown in Table 1 to address the underreporting phenomenon.

5. Estimation Results

We first study the relation between the OAR minor and the selected covariates. Table 5 shows the results obtained with the OLS pooling model (Model 1) – which ignores the presence of provincial effects and treats all variables as exogenous – and with the fixed-effects (FE) (Model 2) and random-effects (RE) (Model 3) estimators – which control for the presence of unobserved heterogeneity at the provincial scale.

Table 5. OLS pooling, fixed effects (FE) and random effects (RE) estimates
(dependent variable: OAR minor)

Variables	Model 1 OAR minor Pooled OLS	Model 2 OAR minor P-FE	Model 3 OAR minor P-RE
Unemployment	-0.215***	-0.221***	-0.208***
	(0.041)	(0.035)	(0.034)
Added value	-0.389***	-0.966***	-0.780***
	(0.139)	(0.222)	(0.185)
Investment/GDP	-2.601***	-0.616***	-0.921***
	(0.442)	(0.207)	(0.207)
Secondary education	0.047	-0.502***	-0.519***
	(0.108)	(0.124)	(0.126)
Micro	0.225***	0.880***	0.445***
	(0.066)	(0.178)	(0.131)
SME	-0.229***	-0.719***	-0.773***
	(0.070)	(0.128)	(0.098)
Employment Risk	0.040	1.046***	0.820***
	(0.054)	(0.187)	(0.123)
Women	-0.938***	-0.130	-0.135
	(0.161)	(0.156)	(0.155)
Youth	0.334***	0.192**	0.228***
	(0.112)	(0.081)	(0.087)
Non regular employed	-0.743***	-0.491***	-0.700***
	(0.090)	(0.116)	(0.113)
Rule of law	-0.099***	-0.079***	-0.095***
	(0.027)	(0.023)	(0.022)
Const.	12.732***	9.646***	12.073***
	(0.927)	(1.774)	(1.402)
F-stat or Wald χ^2	62.72***	47.91***	524.47***
R^2	0.43	0.58	0.21
Groups	106	106	106
Obs.	840	840	840

*Robust standard error in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

As it is showed in Table 5, the results of the pooled OLS, and fixed/random effects panel models obtained are the same regarding the sign of the effect (except for “Secondary education” (positive for Model 1 and negative for Models 2 and 3), and with small differences in magnitude. Overall, the coefficients associated with all the explanatory variables considered are significant in all three estimated models, except for the percentage of "Women” in Models 2 and 3, and “Secondary education” and “Employment risk” in Model 1.

The Hausman’s Test (1978) reveal that the fixed effects model is the most appropriate one (*p-value = 0.000*, through which we reject the null hypothesis that the random effects model is the preferred one), so the following remarks refer to FE model.

The obtained fixed effects estimation confirms what emerges in literature regarding the inverse relationship between occupational injuries and unemployment rates (e.g., Anyfantis et al., 2018; Boone et al., 2011; Boone and van Ours, 2006). The point estimate shows that the OAR minor has a negative sign, so the higher (lower) the unemployment rate, the lower (higher) the OAR minor. It may depend on either a reduction in the number of workers employed, the reluctance of workers to report injuries when their bargaining power against employers is reduced, or both.

The relationship between OAR minor and the added value per capita shows a negative relation, meaning that the higher the value of the added value, the lower the OAR minor, and presumably reflecting a greater propensity to address occupational safety and health issue as economic resources increase[11]. Moreover, since the variable measures the growth of the economic system (in terms of new goods and services available for final use), the negative sign may reflect capital-intensity-led rather than labor-intensity-led growth.

The negative sign associate with the rate of change of investment/GDP confirms what shown in literature, namely the investments’ positive effect on OSH performance (Asfaw et al., 2011; Davies et al., 2009; Boone and van Ours, 2006; Ussif, 2004; Brooker et al., 1997) and the negative relationship with the accident rate (Takala, 2019; Sari et al., 2004; Blank et al., 1996; Asogwa, 1988; Laflamme and Cloutier, 1988).

About the production system characteristics, the coefficient associated with the prevalence of secondary education is statistically significant (at 1% level), and it has the expected sign (negative,

[11] The literature shows a procyclical trend in the rate of occupational injuries (de la Fuente et al., 2014; Asfaw, 2011). However, the relationship between the business cycle and the injury phenomenon is complex and must be empirically tested in a case-specific manner because many factors come into play. In the current era, for example, technological innovation may represent an important growth factor that might not necessarily be positively correlated with the injury phenomenon.

that is, higher levels of education are associated with lower OAR minor). Thus, the skill-effect hypothesis would seem to be supported by the empirical evidence, which is further confirmed by the highly significant and positive coefficient of the "Employment risk" variable (the higher the share of workers in enterprises with a high risk of accident occurrence, the higher the OAR minor). The coefficients associated with firm size is in line with the literature on the topic (Micheli et al., 2018; Nordlöf et al., 2017; Hasle and Limborg, 2006; Champoux and Brun, 2003; Antonsson et al., 2002; Dorman 2000), with "Micro" having a positive sign and "SME" negative sign, both significant at 1% level. Therefore, the occupational accident rate decreases as firm size increases.

About the workforce demography, on one hand, the covariate "Women" show a negative sign, but the non-statistical significance must be stressed. On the other hand, our results show that being a young employee represent a risk factor in occupational injuries occurrence, with positive sign of the estimate coefficient at 5% of significance. This finding confirms that existing literature, which highlights that the age of the worker is a variable influencing exposure to injury risk, and that younger workers are often in the most vulnerable status with respect to OSH (Hanvold et al., 2019; Pouliakas and Theodossiou, 2013; Blanch et al., 2009; Swaen et al., 2004).

Finally, about variables representing legal compliance, the variable "Non regular employed" show a negative sign with 1% of significance, so our results suggest that increasing the non-regular employees leads to a decrease in the OAR minor: apparently, as the number of non-regular employees increases, accidents at work decrease. This conclusion is contrary to what we would expect to follow directly from standard economic reasoning, as a non-regular employees met lower OSH standard in informal economy. What can explain such empirical result? Greater the prevalence of the underground economy, higher the number of unrecorded injuries, and thus the lower the resulting OAR, so the negative sign is the expected one.

Finally, our results show that the presence of higher level of rule of law is associate with lower OAR, confirming the hypothesis that higher compliance with workplace safety regulations led a better OSH performance.

However, as widely described in the literature review section, underreporting of occupational injuries could significantly affect our previous baseline results. The propensity to underreport varies between minor and severe accidents, and it is related to a multidimensional set of characteristics closely related to the business cycle, firm size, labour market fragility, and territorial gradient (Leombruni et al., 2019; Boone et al., 2011; Boone and van Ours, 2006; Palali and van Ours, 2017). Different reporting behaviour could skew the official injury count, and thus be translated into biased

estimates. We provide additional estimates of Eq. 1 by considering two alternative measurements of the occupational accident rates with the aim of minimising the extent of the bias. Particularly, embracing Leombruni et al., 2019), Boone and Van Ours (2006) and Boone et al. (2011) approach, we gradually increase the severity of our dependent variables by focusing on severe and severe plus fatal accident rates.

Table 6 shows the estimated coefficients of the fixed-effects (FE) and random-effects (RE) model for the dependent variables OAR severe and OAR severe & fatal. Again, in the case of the estimates having OAR severe and OAR severe & fatal as dependent variable, the Hausman's test (1978) reveals that the fixed-effects model is the most appropriate (*p-value* = 0.000, through which we reject the null hypothesis that the random-effects model is the preferred one), so the following remarks refer to the FE model. Particularly, a few empirical findings emerge (Table 6).

Table 6. OLS, fixed effects (FE) and random effects (RE) estimates
(Dependent variables: OAR severe and OAR severe & fatal)

Variables	OAR severe P-FE	OAR severe P-RE	OAR severe & fatal P-FE	OAR severe & fatal P-RE
Unemployment	-0.124***	-0.125***	-0.124***	-0.125***
	(0.027)	(0.026)	(0.027)	(0.026)
Added value	-0.698***	-0.707***	-0.698***	-0.708***
	(0.176)	(0.150)	(0.176)	(0.150)
Investment/GDP	-0.323*	-0.411**	-0.321*	-0.410**
	(0.168)	(0.166)	(0.169)	(0.167)
Secondary education	-0.322***	-0.294***	-0.317***	-0.290***
	(0.089)	(0.089)	(0.089)	(0.090)
Micro	0.740***	0.689***	0.743***	0.691***
	(0.151)	(0.113)	(0.152)	(0.113)
SME	-0.404***	-0.510***	-0.407***	-0.513***
	(0.110)	(0.091)	(0.110)	(0.091)
Employment Risk	0.653***	0.473***	0.655***	0.474***
	(0.155)	(0.106)	(0.155)	(0.105)
Women	-0.173	-0.149	-0.185*	-0.162
	(0.107)	(0.105)	(0.106)	(0.104)
Youth	0.134**	0.139**	0.133**	0.137**
	(0.060)	(0.064)	(0.061)	(0.065)
Non regular employed	-0.214**	-0.282***	-0.218**	-0.284***
	(0.107)	(0.101)	(0.107)	(0.101)
Rule of law	-0.048***	-0.066***	-0.047***	-0.066***

	(0.017)	(0.016)	(0.017)	(0.016)
Const.	7.688***	8.901***	7.724***	8.953***
	(1.526)	(1.343)	(1.532)	(1.347)
F-stat or Wald χ^2	47.72***	526.50***	47.91***	524.47***
R^2	0.58	0.19	0.58	0.19
Groups	106	106	106	106
Obs.	840	840	840	840

Robust standard error in parentheses: *** p<0.01, ** p<0.05, * p<0.1

This additional set of estimates confirms the overall reliability of the model presented in Table 5. Looking more closely at the results presented in Table 6, we observe that, even for severe and severe & fatal accidents, the signs and statistical significance of the estimated parameters of our control variables remain unchanged from previous results, although the magnitude of the parameter is generally smaller in absolute value (except for the variables “Women”). In other words, the underreporting bias, in this scenario in which the most severe accidents are considered to measure our dependent variable, does not affect the overall interpretation of our results, but it does change the magnitude of the effect exerted by our determinants on the phenomenon of occupational injuries.

First, the negative effect of unemployment on OAR severe and severe & fatal is lower than on OAR minor. The different magnitude of the unemployment effect could be explained by the different reporting behaviour between minor and more severe accident. In fact, with high unemployment rates, employees could be more likely not to report incidents because of the threat of losing their jobs and not being able to find other employment. So, this finding is coherent with the existing literature (Leombruni et al., 2019; Boone et al., 2011; Boone and van Ours, 2006) according to which high unemployment led to lower propensity to report less severe accidents. Concerning the other business cycle variables, the sign of both the " Added Value" and "Investment/GDP" effect is negative (at the 1% and 10% level respectively), confirming what we found for the OAR minor. However, the downward pattern of injuries has different magnitudes depending on the heterogeneous intensity of the severity of occupational injuries considered: the magnitude of the effect is lower than the previous estimate. This result could suggest that previous result (with OAR minor as a dependent variable) is overestimate because of possible underreporting behaviour of minor injuries.

Regarding the skill-effect hypothesis, “Secondary education” and “Employment risk” confirm previous result with the same statically significance (at 1% level) in all Model specifications, so

further confirmation is found. However, the estimate coefficients are lower. Given the possible bias for minor accidents (depending on possible higher level of underreporting behaviours), the magnitude estimated in Table 6 is considered more realistic.

It is then observed that company size confirms to have an inverse relationship with the accident phenomenon as widely shown in literature (Micheli et al., 2018; Nordlöf et al., 2017; Fabiano et al., 2004; Morse et al., 2004; Antonsson et al., 2002 Leigh, 1989; Oleinick et al., 1995). What is interesting is the different magnitude for both covariates controlling for firm size. In fact, the present analysis do not confirm the literature according to which?? larger firms are more inclined to report work-related injuries than their smaller counterparts (Boone et al., 2011; Boone and van Ours, 2006; Fabiano et al. 2004; Morse et al., 2004; Oleinick et al., 1995): the variable "Micro" shows a positive coefficient slightly lower in table 6 than in table 5, suggesting that the reporting behaviour is quite similar between minor and more severe accidents if the worker is employed in a micro enterprise. Also, the coefficient associated with the variable "SME" is smaller in Table 6 than in Table 5. It implies that underreporting bias might exist in larger enterprises. This could be related to the fact that stricter employment protection legislation[12] (EPL) existing for larger firms does not unambiguously affect labour market outcomes (Schivardi and Torrini, 2008), and that strict regulation may be associated with greater labour supply elasticity, despite the higher costs of achieving flexibility (Hijzen et al., 2017). In other words, as shown by Belloc and D'Antoni (2020) in the Italian framework, firms above the 15-employee threshold experience surprisingly high turnover rates compared to firms below the threshold. Such flexibility on the firm's side, could translate on the worker's side into less job security (Galizzi et al., 2019), and consequently in worst OSH

[12] The Italian employment protection legislation (Law No. 300 of 1970, "Statuto dei Lavoratori"), whereby enterprises with fewer than 15 employees are subject to relatively milder mechanisms for firing workers and workers' rights to form unions. In. particular, workers had the right to appeal to the court if their permanent contract had been terminated without a "just cause" ("giusta causa," i.e., serious misconduct of the worker or economic difficulties of the company). If the court found the dismissal unfair, the consequences for the worker vary depending on the size of the company: in companies with more than 15 employees, a worker dismissed without just cause had to be compensated for unpaid wages in the period between the dismissal and the court's decision. In addition, the judge may impose reinstatement of the worker or a severance payment (15 months' salary). In companies with fewer than 15 employees, employers faced less strict regulations and lower severance pay in the case of unfair dismissal, and the judge could not impose reinstatement of the unfairly dismissed worker. In addition, the worker is not compensated for lost earnings in the period between the dismissal and the judge's decision. According to the same legislation, in companies with more than 15 employees, workers have stronger rights in terms of representative body formation and power allowed to unions in negotiations. The right of workers to establish representative bodies to negotiate on wage levels is guaranteed in companies with more than 15 employees. The 15-employee threshold is also relevant for the establishment of so-called "Company Trade Union Representatives" (“Rappresentanze Sindacali Aziendali”, RSA). Workers in companies with more than 15 employees can elect company-level union representatives (RSA), who are allowed to be absent from work for union activities and can call general meetings, post posters on union activities, and call referendums (D’ambrosio et al., 2021).

conditions. In fact, as Probst et al. (2013) suggest, not only does job insecurity correlate with the likelihood of an injury[13], but also the perception of job insecurity may serve to inhibit the reporting of injuries, (especially if minor) to official account. However, the relationship involving microenterprises needs to be deepened, possibly with a specific analysis focusing only on enterprises below the 15-employee threshold[14].

About the workforce demography, as in the previous estimate (Table 5) "Women" is non-statistically significant for OAR severe as a dependent variable but show a negative and statistically significant (at 10% level) effect for OAR severe & fatal, confirming the literature stating that high injury risk sectors, such as construction, transportation, industry, and agriculture, remain male-dominated (Biswas et al., 2021; Parent-Thirion et al., 2016; Eng et al., 2011). Moreover, youth employment is confirmed to represent a risk factor in occupational injuries occurrence, with positive sign of the estimate coefficient at 1% of significance, but with lower magnitude for severe and severe & fatal accidents. The change in the magnitude the coefficient related to "Youth" would need further investigation.

The variable "Non regular employed" display again a negative sign with 1% of significance. In addition, the smaller estimated coefficient confirms the underreporting hypothesis. In fact, severe injuries are difficult to hide and fatal injuries impossible to hide. Thus, although the noncompliance variable confirms lower injury reporting behaviour, the effect is smaller for this type of injury, exactly as suggested by the smaller magnitude resulting from the estimated.

Finally, the compliance index territorial variable has a significant effect on the phenomenon and, therefore, seems to confirm the inverse relationship between compliance with occupational safety regulations and illegality.

6. Conclusions

This work address two main issues. First, it proposes an empirical analysis at the Italian provincial level of the occupational accidents' phenomenon using Inail and ISTAT data for the period 2011-2019. Following the international literature (Cornelissen et al., 2017; Fabiano et al., 2004; Laflamme, 1990), covariates are identified to address the complexity of the phenomenon of the workplace

[13] The higher risk of occupational injuries for workers with fixed term contract is due to the fact that i) they have less experience of the workplace, ii) that firms have less incentive to provide them with job safety training, iii) or because temporary workers may be employed in more dangerous tasks (Picchio and van Ours, 2017; Tucker et al., 2014; Guadalupe, 2003).

[14] In addition, "PMI" variable aggregate firms from 10 to 250 FTE. Therefore, further investigation with more detailed subgroup of firms' size will be carry out.

accidents. Particularly, we use business cycle related variables (unemployment, added value, investments/GDP), variables related to the territorial production system (firms' size, level of education, employment in riskiest sectors) and to workforce demography (female employment and youth employment) and finally, variables proxied to the institutional context (such as, the presence of non-regular employment positions and the perception of legal compliance).

Second, embracing Leombruni et al. (2019), Boone et al., 2011, and Boone van Ours (2006) approach, we test the underreporting hypothesis, examining the case that rates of minor injury can be explained by both working conditions and the willingness of workers to report injuries (Davies et al., 2009) and therefore, the analysis of just minor injuries can lead to distorted conclusions. In fact, reporting behaviour of occupational injuries varies between minor and more serious occupational injuries – serious injuries being more difficult to hide than minor injuries, and fatal injuries impossible to hide. So, as dependent variable, we initially use the OAR minor and then we deepen the analysis using the OAR of the severe accidents, and finally to the OAR of severe plus fatal accidents.

Our results suggest that the business cycle, at Italian provincial level, has an impact on occupational injuries and that this effect acts through several channels. Unemployment rate shows a negative relationship with occupational accidents, but with lower magnitude for severe and severe & fatal accidents according to the underreporting hypotheses also highlighted in the literature on the underreporting phenomenon (Leombruni et al.,2019; Boone et al., 2011; Boone and van Ours, 2006). Thus, although estimates show a decrease in the accident incidence due trivially to the erosion of the extensive margin of the labour force (Davies et al., 2014), they also confirm a reluctance to report injuries where employees' bargaining power versus employers is reduced. This result would seem to suggest the need for greater workers' protection in times of high unemployment to foster behavioural improvement in terms of accident reporting. Such an improvement in accidents reporting could led to increased OSH investment even during a recession, since the cyclical fluctuations in reporting behaviour could also influence the entrepreneurs' OSH investment decisions (Boone et al., 2011). This is particularly important in the light of the empirical evidence according to the statistically significant negative relationship found in our empirical analysis: the higher the rate of change of fixed investment, the lower the OAR, whatever its specification, which confirms what emerges in literature (Asfaw et al., 2011; Davies et al., 2009; Boone and van Ours, 2006; Ussif, 2004; Brooker et al., 1997). In addition, our result shows that a

higher added value presumably reflects a greater propensity to address occupational safety and health issue, and, in this way, it exerts an effect decreasing the OAR.

Even at the Italian provincial level, firm size is inversely correlated with the accident phenomenon. The sign of the coefficients associated with “Micro“ (positive) and “SME” (negative) shows that being employed in a company with fewer than 10 employees poses a greater risk of occupational injury than its larger counterparts. However, an underreporting bias could exist in larger firms. Given the Italian employment protection legislation, firms above the 15-employee threshold, even if firms subject to stricter regulation, experience surprisingly high turnover rates with respect to firms below the threshold through the use of flexible employment contract (Belloc and D'Antoni, 2020; Hijzen et al., 2017; Schivardi and Torrini, 2008), and this poses temporary workers in a vulnerable position, inducing them to underreport less severe injuries. Underreporting occurs because workers are afraid that reporting an accident may lead to job loss or denial of promotion, according to the literature stating that accident underreporting is more relevant when workers' perception of job insecurity is larger (Probst et al., 2013).

The level of education is inversely correlated with the accident phenomenon, presumably reflecting a better physical working environment with reference to higher levels of education. So, the skill effect (Walters and Wadsworth, 2016; Parent-Thirion et al. 2012; Khanzode et al., 2011; Haslam et al., 2005) on occupational accidents is confirmed, and the positive and highly statistically significant coefficient for “Employment risk” corroborates this hypothesis.

About workforce demography, on the one hand, our study confirms a slightly lower risk of occupational accidents occurrence for female workers (such evidence emerges only for severe plus fatal), weakly confirming the widespread literature stating that industries with a high risk of injury occurrence are highly male-dominated (Biswas et al., 2021; Parent-Thirion et al., 2016; Eng et al., 2011). On the other hand, it emerges that young workers seem to be in a vulnerable status with respect to OSH (Hanvold et al., 2019; Tucker et al., 2014; Pouliakas and Theodossiou, 2013; Blanch et al., 2009; Swaen et al., 2004).

Furthermore, the results confirm the relevance of the quality of the institutions, with reference to the compliance with regulatory provisions, which our proxy variable “Rule of law” tries to capture. The other compliance variable, "Non regular employed," could suggests that underreporting behaviour exists in the Italian territory.

The presented evidence reveals that cyclical fluctuation in injury rates are caused by the combination of three factors: i) variations in OSH conditions, ii) changes in the composition of the

workforce in terms of tenure and precariousness, and iii) the workers' willingness of to report minor injuries.

From an economic policy perspective our findings suggest to enhancing OSH intervention, particularly during a downturn, when lower bargaining power of workers could mean less opportunity to negotiate more OSH claims, resulting in worsening occupational health and safety conditions. In addition, one way to bring the economy closer to the social optimum would be to introduce measures that prevent discrimination in the dismissal of workers who have reported an accident, and policies intended to promote the fair injuries' reporting by employees are necessary to avoid inconsistent reporting through the business cycle (Davies et al., 2009).

This topic takes on even greater relevance in Italy during actual economic phase – i.e., post COVID-19 pandemic., which was the first country to be affected by the pandemic and consequently to suffer greater economic consequences. Currently, do regulatory remedies (statutory occupational health and safety standards and/or penal regulations) and indirect policies (sermons, training, etc.) alone have the potential to improve OSH levels? Our analysis suggests that, especially in economic downturns, selective public policies geared toward supporting OSH investments should be a complementary tool to conventional policy options.

Our results also indicate that policies should focus to most vulnerable workforce, as low-paid, low-skilled, precarious, and young workers, for example, improving training for new entrants and controlling the integration of unskilled workers into the production process (Davies et al., 2009).

However, the analysis shows that further decomposition of the business cycle would be required to ascertain the relative magnitude of each effect. This leads, on the one hand, to the emergence of future research perspectives for the necessary deepening of certain aspects and, on the other hand, to possible policy indications. Specifically, a more specific in-depth analysis of the occupational injury phenomenon is needed for younger workers and for enterprises below the 15-employee threshold.

References

Alamgir, H., Koehoorn, M., Ostry, A., Tompa, E., & Demers, P. (2006). *An evaluation of hospital discharge records as a tool for serious work related injury surveillance*. Occupational and Environmental Medicine, 63(4), 290-296.

Alessandrini B., Nunin R., Poles A., Venturini S., Zuliani Conti C. (a cura di) (2017). *Modelli organizzativi e gestionali per la sicurezza sul lavoro. Analisi empirica e prospettive applicative*, Trieste, Edizioni Nuova Trieste.

Anyfantis, I., Boustras, G., & Karageorgiou, A. (2018). *Maintaining occupational safety and health levels during the financial crisis–A conceptual model*. Safety science, 106, 246-254.

Antonsson, A. B., Birgersdotter, L., & Bornberger-Dankvardt, S. (2002). *Small enterprises in Sweden: Health and safety and the significance of intermediaries in preventive health and safety*.

Asogwa S.E. (1988). *The health benefits of mechanization at the Nigerian coal corporation*. Accid. Anal. Prev., 20 (1): 103–108.

Asfaw, A., Pana-Cryan, R., & Rosa, R. (2011). *The business cycle and the incidence of workplace injuries: Evidence from the USA*. Journal of safety research, 42(1), 1-8.

Benavides F.G., J. Benach, C. Muntaner, G.L. Delclos, N. Catot, M. Amable (2006). *Associations between temporary employment and occupational injury: what are the mechanisms?* Occupational Environmental Medicine, 63(6): 416–21.

Biswas, A., Harbin, S., Irvin, E., Johnston, H., Begum, M., Tiong, M., Apedaile, D., Koehoorn, M. & Smith, P. (2021). *Sex and gender differences in occupational hazard exposures: a scoping review of the recent literature*. Current environmental health reports, 1-14.

Blanch, A., Torrelles, B., Aluja, A., & Salinas, J. A. (2009). *Age and lost working days as a result of an occupational accident: A study in a shiftwork rotation system*. Safety Science, 47(10), 1359-1363.

Blank, V. L., Diderichsen, F., & Andersson, R. (1996). *Technological development and occupational accidents as a conditional relationship: A study of over eighty years in the Swedish Mining industry*. Journal of Safety Research, 27(3), 137-146.

Boone, J., Van Ours, J. C. (2006). *Are recessions good for workplace safety?*. Journal of Health economics, 25(6), 1069-1093.

Boone, J., Van Ours, J. C., Wuellrich, J. P., & Zweimüller, J. (2011). *Recessions are bad for workplace safety*. Journal of health economics, 30(4), 764-773.

Brooker A. S., J. Frank, V.S. Tarasuk (1997). *Back pain claim rates and the business cycle*. Social Science and Medicine, 45(3), 429−439.

Campos-Serna, J., Ronda-Pérez, E., Artazcoz, L., Moen, B. E., & Benavides, F. G. (2013). *Gender inequalities in occupational health related to the unequal distribution of working and employment conditions: a systematic review*. International journal for equity in health, 12, 1-18.

Champoux, D., & Brun, J. P. (2003). *Occupational health and safety management in small size enterprises: an overview of the situation and avenues for intervention and research*. Safety science, 41(4), 301-318.

Conti, P. (2016). *Il genere nella salute e sicurezza sul lavoro: la visione sistemica delle scienze sociali*. Perspectives. 2(1), 37-41.

Cornelissen, P. A., Van Hoof, J. J., & De Jong, M. D. (2017). *Determinants of safety outcomes and performance: A systematic literature review of research in four high-risk industries*. Journal of Safety Research, 62, 127-141.

D'Ambrosio A., Leombruni, R., & Razzolini, T. (2021). "*Fear Is the Path to the Dark Side". Electoral Results and the Workplace Safety of Immigrants* (No. 14322). Institute of Labor Economics (IZA).

Davies R., P. Jones, I. Nuňez (2009). *The impact of the business cycle on occupational injuries in the UK.* Social Science and Medicine, 69, 178-182.

de La Fuente V.S., Camino López, M. A., Fontaneda González, I., González Alcántara, O. J. & Ritzel, D. O. (2014). *The impact of economic crisis on occupational injuries*. Journal of Safety Research, 48, 77-85.

Delogu A. (2018). *L'asseverazione dei modelli di organizzazione e di gestione della sicurezza sul lavoro di cui all'art. 30 del d.lgs. n. 81/2008: analisi e prospettive 2018*. Diritto della Sicurezza sul Lavoro, 1, 7-51.

Dembe, A. E., Erickson, J. B., Delbos, R. G., & Banks, S. M. (2005). *The impact of overtime and long work hours on occupational injuries and illnesses: new evidence from the United States*. Occupational and environmental medicine, 62(9), *588-597.*

De Sario B., Di Nunzio D., Leonardi S. (2021). Azione sindacale e contrattazione collettiva per la tutela della salute e sicurezza sul lavoro nella fase 1 dell'emergenza da pandemia di Covid-19. Rivista giuridica del lavoro e della previdenza sociale, 1, 91-110.

Deléchat, C., & Medina L., (2021). *The Global Informal Workforce: Priorities for Inclusive Growth*. Washington, DC: International Monetary Fund.

Dorman, P. (2000). *The economics of safety, health, and well-being at work: an overview*. Geneva: ILO.

Dupré D. (2001). *Accidents at Work in the EU – 1998-1999. Statistics in Focus: Population and Social Conditions*. Eurostat Theme 3 – 16/2001, Luxembourg: Publications Office of the European Union.

European Commission (2008). *Employment in Europe 2008*. Directorate-General for Employment, Social Affairs and Equal Opportunities.

Eng, A., Mannetje, A. T., McLean, D., Ellison-Loschmann, L., Cheng, S., & Pearce, N. (2011). *Gender differences in occupational exposure patterns*. Occupational and environmental medicine, 68(12), 888-894.

Fabiano, B., Currò, F., & Pastorino, R. (2004). *A study of the relationship between occupational injuries and firm size and type in the Italian industry*. Safety science, 42(7), 587-600.

Fabiano, B., Currò, F., Reverberi, A. P., & Pastorino, R. (2008). *A statistical study on temporary work and occupational accidents: Specific risk factors and risk management strategies*. Safety science, 46(3), 535-544.

Folkard, S., & Lombardi, D. A. (2006). *Modeling the impact of the components of long work hours on injuries and "accidents"*. American journal of industrial medicine, 49(11), 953-963.

Galizzi, M., Leombruni, R., & Pacelli, L. (2023). *Severe work disabilities and long-lasting losses*. Labour Economics, 85, 102432.

Galizzi, M., Leombruni, R., & Pacelli, L. (2019). *Successful return to work during labor market liberalization: the case of Italian injured workers*. Journal for Labour Market Research, 53(1), 9

Giraudo, M., Bena, A., Mosca, M., Farina, E., Leombruni, R., & Costa, G. (2019). *Differences in work injury risk between immigrants and natives: changes since the economic recession in Italy*. BMC public health, 19, 1-11.

Guadalupe, M. (2003*). The hidden costs of fixed term contracts: the impact on work accidents*. Labour economics, 10(3), 339-357.

Hanvold, T. N., Kines, P., Nykänen, M., Thomée, S., Holte, K. A., Vuori, J., Wærsted, M. & Veiersted, K. B. (2019). *Occupational safety and health among young workers in the Nordic countries: a systematic literature review*. Safety and health at work, 10(1), 3-20.

Haslam, R. A., Hide, S. A., Gibb, A. G., Gyi, D. E., Pavitt, T., Atkinson, S., & Duff, A. R. (2005). *Contributing factors in construction accidents*. Applied ergonomics, 36(4), 401-415.

Hasle, P., & Limborg, H. J. (2006). *A review of the literature on preventive occupational health and safety activities in small enterprises*. Industrial health, 44(1), 6-12.

Hasle, P., Limborg, H. J., Kallehave, T., Klitgaard, C., & Andersen, T. R. (2012). *The working environment in small firms: Responses from owner-managers*. International Small Business Journal, 30(6), 622-639.

Hijzen, A., Mondauto, L., & Scarpetta, S. (2017). *The impact of employment protection on temporary employment: Evidence from a regression discontinuity design*. Labour Economics, 46, 64-76.

Ipsen, C., Gish, L., & Poulsen, S. (2015). *Organizational-level interventions in small and medium-sized enterprises: Enabling and inhibiting factors in the PoWRS program*. Safety Science, 71, 264-274.

Irastorza, X., Milczarek, M., & Cockburn, W. (2016). *Second European Survey of Enterprises on New and Emerging Risks (ESENER-2): overview report: managing safety and health at work*. Publications Office of the European Union. Available at the following link https://www.istat.it/it/archivio/244848.

Khanzode, V. V., Maiti, J., & Ray, P. K. (2011). *A methodology for evaluation and monitoring of recurring hazards in underground coal mining*. Safety Science, 49(8-9), 1172-1179.

Kogi, K. (2002). *Work improvement and occupational safety and health management systems: common features and research needs*. Industrial health, 40(2), 121-133.

Koukiadaki, A., & Kretsos, L. (2012). *Opening Pandora's box: The sovereign debt crisis and labour market regulation in Greece*. Industrial Law Journal, 41(3), 276-304.

Laflamme, L. (1990). *A better understanding of occupational accident genesis to improve safety in the workplace*. Journal of occupational accidents, 12(1-3), 155-165.

Laflamme L., E. Cloutier (1988). *Mechanization and risk of occupational accidents in the logging industry*. Journal of Occupational Accidents, 10: 191–198.

Leigh, J. P. (1989). *Firm size and occupational injury and illness incidence rates in manufacturing industries*. Journal of Community Health, 14(1), 44-52.

Leigh, J. P., Marcin, J. P., & Miller, T. R. (2004). *An estimate of the US government's undercount of nonfatal occupational injuries*. Journal of Occupational and Environmental Medicine, 46(1), 10-18.

Lenaerts, K., Vandekerckhove, S., Lamberts, M., Seghir, M., Mofakhami, M., & Greenan, N. (2020). *Working Conditions in Sectors*. Publications Office of the European Union.

Leombruni, R., Razzolini, T., & Serti, F. (2019). *Macroeconomic conditions at entry and injury risk in the workplace*. The Scandinavian Journal of Economics, 121(2), 783-807.

Lindroos, O., Aspman, E. W., Lidestav, G., & Neely, G. (2008). *Accidents in family forestry's firewood production*. Accident analysis & prevention, 40(3), 877-886.

Lilley, R., Feyer, A. M., Kirk, P., & Gander, P. (2002). *A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury?*. Journal of safety research, 33(1), 53-71.

Lopez M.A.C., D.O. Ritzel, I. Fontaneda, O.J.G. Alcantara (2008). *Construction industry injuries in Spain*. Journal of Safety Research, 39(5): 497–507.

Maiti, J., & Bhattacherjee, A. (1999). *Evaluation of risk of occupational injuries among underground coal mine workers through multinomial logit analysis*. Journal of Safety Research, 30(2), 93-101.

Maiti, J., Bhattacherjee, A., & Bangdiwala, S. I. (2001). *Loglinear model for analysis of cross-tabulated coal mine injury data*. Injury control and safety promotion, 8(4), 229-236.

Maiti, J., Chatterjee, S., & Bangdiwala, S. I. (2004). *Determinants of work injuries in mines–an application of structural equation modelling*. Injury control and safety promotion, 11(1), 29-37.

Micheli, G. J., Cagno, E., & Calabrese, A. (2018). *The transition from occupational safety and health (OSH) interventions to OSH outcomes: An empirical analysis of mechanisms and contextual factors within small and medium-sized enterprises*. International Journal of environmental research and public health, 15(8), 1621.

Mohammadfam, I., Kamalinia, M., Momeni, M., Golmohammadi, R., Hamidi, Y., & Soltanian, A. (2017). *Evaluation of the quality of occupational health and safety management systems based on key performance indicators in certified organizations*. Safety and health at work, 8(2), 156-161.

Morassaei, S., Breslin, F. C., Shen, M., & Smith, P. M. (2013). *Examining job tenure and lost-time claim rates in Ontario, Canada, over a 10-year period, 1999–2008*. Occupational and environmental medicine, 70(3), 171-178.

Morse, T., Dillon, C., Weber, J., Warren, N., Bruneau, H., & Fu, R. (2004). *Prevalence and reporting of occupational illness by company size: population trends and regulatory implications*. American Journal of Industrial Medicine, 45(4), 361-370.

Nifo, A., & Vecchione, G. (2014). *Do institutions play a role in skilled migration? The case of Italy*. Regional studies, 48(10), 1628-1649.

Nordlöf, H., Wiitavaara, B., Högberg, H., & Westerling, R. (2017). *A cross-sectional study of factors influencing occupational health and safety management practices in companies*. Safety science, 95, 92-103.

Oates, W. (1972). *Fiscal federalism*. New York, Harcourt Brace Jovanovich.

Oleinick, A., Gluck, J. V., & Guire, K. E. (1995). *Establishment size and risk of occupational injury.* American journal of industrial medicine. 28(1), 1-21.

Orsi, R., Raggi, D., & Turino, F. (2014). *Size, trend, and policy implications of the underground economy*. Review of Economic Dynamics, 17(3), 417-436.

Palali, A., & van Ours, J. C. (2017). *Workplace accidents and workplace safety: on under-reporting and temporary jobs*. Labour, 31(1), 1-14.

Parent-Thirion, A., Biletta, I., Cabrita, J., Vargas Llave, O., Vermeylen, G., Wilczyńska, A., & Wilkens, M. (2016*). Sixth European working conditions survey–overview report*.

Parent-Thirion, A., Vermeylen, G., & Houten, G. V. (2012). *Publications Office of the European Union*. Luxembourg, S, 158.

Pascucci P., Delogu A. (2020). *Sicurezza sul lavoro nella PA nell'emergenza da Covid-19*. Sinappsi, n.1, 131-143.

Pedersen, L. M., Nielsen, K. J., & Kines, P. (2012). *Realistic evaluation as a new way to design and evaluate occupational safety interventions*. Safety science, 50(1), 48-54.

Picchio, M., & Van Ours, J. C. (2017). *Temporary jobs and the severity of workplace accidents.* Journal of safety research, 61, 41-51.

Pouliakas, K., & Theodossiou, I. (2013). *The economics of health and safety at work: an interdiciplinary review of the theory and policy*. Journal of Economic Surveys, 27(1), 167-208.

Probst, T. M., Barbaranelli, C., & Petitta, L. (2013). *The relationship between job insecurity and accident under-reporting: A test in two countries*. Work & Stress, 27(4), 383-402.

Robinson, J. C. (1988). *The rising long-term trend in occupational injury rates*. American Journal of Public Health, 78(3), 276-281.

Ruhm, C. J. (2000). *Are recessions good for your health?*. The Quarterly journal of economics, 115(2), 617-650.

Sánchez, A. S., Fernández, P. R., Lasheras, F. S., de Cos Juez, F. J., & Nieto, P. G. (2011). *Prediction of work-related accidents according to working conditions using support vector machines*. Applied Mathematics and Computation, 218(7), 3539-3552.

Sari M., H. Duzgun, C. Karpuz, A. Selcuk (2004). *Accident analysis of two Turkish underground coal mines*. Safety Science, 42: 675–690.

Schneider, F. (2010). *The influence of public institutions on the shadow economy: An empirical investigation for OECD countries*. Review of Law & Economics, 6(3), 441-468.

Schneider, F., & Asllani, A. (2022). *Taxation of the Informal Economy in the EU*. European Parllament, Subcommittee on tax matters (FISC).

Schneider, F., & Buehn, A. (2012). *Shadow economies in highly developed OECD countries: What are the driving forces?*.

Schneider, F., & Enste, D. H. (2000). *Shadow economies: Size, causes, and consequences*. Journal of economic literature, 38(1), 77-114.

Sclip G. (a cura di) (2019). *Sicurezza accessibile. La sicurezza sul lavoro in una prospettiva di genere*, Trieste, Edizioni Nuova Trieste.

Schivardi, F., & Torrini, R. (2008). *Identifying the effects of firing restrictions through size-contingent differences in regulation*. Labour Economics, 15(3), 482-511.

Shannon, H. S., & Lowe, G. S. (2002). *How many injured workers do not file claims for workers' compensation benefits?*. American journal of industrial medicine, 42(6), 467-473.

Shannon, H. S., Walters, V., Lewchuk, W., Richardson, J., Moran, L. A., Haines, T., & Verma, D. (1996). *Workplace organizational correlates of lost-time accident rates in manufacturing*. American journal of industrial medicine, 29(3), 258-268.

Sinclair, R. C., Cunningham, T. R., & Schulte, P. A. (2013). *A model for occupational safety and health intervention diffusion to small businesses*. American journal of industrial medicine, 56(12), 1442-1451.

Swaen, G. M. H., Van Amelsvoort, L. P. G. M., Bültmann, U., Slangen, J. J. M., & Kant, I. J. (2004). *Psychosocial work characteristics as risk factors for being injured in an occupational accident*. Journal of occupational and environmental medicine, 46(6), 521-527.

Simona Talani, L. (2019). *Assessing the relation between the underground economy and irregular migration in Italy*. The International Spectator, 54(2), 102-122.

Takala, J. (2019). *Burden of injury due to occupational exposures*. Handbook of disability, work and health, 1-22

Tucker, S., Diekrager, D., Turner, N., & Kelloway, E. K. (2014). *Work-related injury underreporting among young workers: prevalence, gender differences, and explanations for underreporting*. Journal of safety research, 50, 67-73.

Tullini P. (2017). *La formazione per la sicurezza sul lavoro*. Diritto della Sicurezza sul Lavoro, 1, 75-85.

Ussif A.A. (2004). *An international analysis of workplace injuries*. Monthly Labor Review, 127, 41-51.

Vassie, L., Tomàs, J. M., & Oliver, A. (2000). *Health and safety management in UK and Spanish SMEs: a comparative study*. Journal of Safety Research, 31(1), 35-43.

Virtanen M., M. Kivimäki, M. Joensuu, P. Virtanen, M. Elovainio, J. Vahtera (2005). *Temporary employment and health: a review*. International Journal of Epidemiology, 34(3): 610–22.

Walters, D., Nichols, T., Connor, J., Tasiran, A., & Cam, S. (2005). *The role and effectiveness of safety representatives in influencing workplace health and safety*.

Walters, D., & Wadsworth, E. J. (2016). *Contexts and arrangements for occupational safety and health in micro and small enterprises in the EU-SESAME projects*.

Wu, D. F., & Schneider, F. (2021). *Nonlinearity between the Shadow Economy and Economic Development.* The Global Informal Workforce, 85.