South African Journal of Economic and Management Sciences
ISSN: (Online) 2222-3436, (Print) 1015-8812

A systematic review of the relationship between economic growth and occupational accidents

Author:
Pablo C. Gutiérrez-Falcón[1]

Affiliation:
[1]Faculty of Industrial Engineering, Occupational Health and Safety Engineering Program, Universidad Nacional Mayor de San Marcos, Lima, Peru

Corresponding author:
Pablo Gutiérrez-Falcón,
pgutierrezf@unmsm.edu.pe

Dates:
Received: 25 Feb. 2025
Accepted: 13 Aug. 2025
Published: 30 Sept. 2025

How to cite this article:
Gutiérrez-Falcón, P.C., 2025, 'A systematic review of the relationship between economic growth and occupational accidents', *South African Journal of Economic and Management Sciences* 28(1), a6144. https://doi.org/10.4102/sajems.v28i1.6144

Background: Occupational health and safety are influenced by a range of internal and external factors, among which economic conditions are particularly salient. However, existing research has largely focused on internal determinants.

Aim: This study systematically examined the relationship between economic growth and occupational accidents, with a particular focus on the mechanisms linking macroeconomic dynamics to workplace safety outcomes.

Setting: The review drew on 19 international studies published between 2000 and 2020.

Method: A quantitative approach was adopted, employing systematic mapping to identify studies published in the following databases: EBSCOhost, DynaMed, IEEE Xplore, IOP, SAGE, Scopus, ScienceDirect, Taylor & Francis and Wiley.

Results: Only six European countries, four Asian and one in the Americas have conducted such research; these studies utilise a range of macroeconomic and occupational health and safety variables to examine the relationship between economic growth and occupational accidents.

Conclusion: Evidence from several developed and high-income countries in Europe, Asia and North America suggests a direct effect of economic growth on the incidence of occupational accidents.

Contribution: This review synthesises research from 2000 to 2020 on external economic factors and their impact on occupational accidents. The body of evidence remains sparse, despite early work dating back to 1938. Further research is needed, particularly in African and Latin American developing countries.

Keywords: economics factor; economic growth; occupational accidents; occupational safety and health; occupational accidents.

Introduction

Occupational health and safety are affected by internal factors, such as the safety climate and the management system, and external factors, such as economic and technological developments and social and political factors (Chang, Chen & Tsai 2018; Gümüş & Gülsün 2020). Occupational safety and health conditions are generally better in developed countries compared to developing nations (Song, He & Li 2011). According to the International Labour Organisation, the mortality rate per 100 000 workers is 4 in developed countries but exceeds 10 in developing ones. However, there are studies that warn of the need for greater support for prevention as a tool for reducing occupational accidents (Teixidó i Campàs 2009), given that poor occupational safety and health practices cost approximately 4% of the global Gross Domestic Product each year.

The prevention of accidents at work has its origins in the work of Heinrich (Sousa, Almeida & Dias 2014), who defined the sequential model 'Domino Theory', which states that an accident is the result of a series of factors, amongst them, the socioeconomic factor. Similarly, epidemiological models postulate that the occurrence of occupational accidents is influenced by multiple factors, which form a triangular structure, with the socioeconomic factor being one of the corners of this triangle (Gordon 1949; Swuste et al. 2014).

McDaid and Suhrcke (2012) point out that there are a significant number of studies on occupational health and safety management systems in various types of organisations. Similarly, Riaño-Casallas and Palencia-Sánchez (2016) note that research in this field has focused on cost–benefit analyses of interventions, the examination of costs associated with occupational accidents and diseases, and their relationship with productivity. However, these authors consider that the topic of economics

and occupational health and safety remains rather underdeveloped, despite the fact that the first studies on the occurrence of occupational accidents in times of economic expansion were carried out by Kossoris (1938). He found a pro-cyclical relationship between accidents and employment in the US manufacturing sector, establishing four factors:

- Incorporation of new and inexperienced labour during economic booms because of increased labour demand.
- Increased labour intensity during economic booms to meet growing demand.
- Use of old assets during upturns to meet additional demand, such as old and unsafe machinery.
- Increased underreporting (notification) of occupational accidents in recessionary periods because of fear of losing one's job.

Subsequently, Kahraman, Akay and Kılıç (2019) identified five key factors that influence the occurrence of occupational accidents: employer, workplace, employee, public policy and economic factors. However, it can be inferred that the economic factor has a transversal impact on the others. Evidence from multiple contexts suggests that during economic expansions, occupational accident trends can vary. Some studies reported that the number of occupational accidents tends to decrease as labour becomes a scarce resource. In such contexts, employees are in a favourable position to demand and obtain improvements in working conditions (Nichols, Dennis & Guy 1995), while employers are reluctant to incur the high costs associated with absenteeism or employee turnover (Steele 1974). Conversely, during economic recessions, employees often remain persistently trapped in low-quality jobs involving hazardous tasks (Leombruni, Razzolini & Serti 2019). In this regard, the economic situation also serves as a reference framework for the state to establish laws and regulations, including those aimed at preventing occupational accidents. The implementation of such regulations constitutes a legal responsibility for both employers and employees.

The economic factor plays a crucial role in occupational accidents. Rapidly growing economies may face challenges in safeguarding workers from occupational hazards. For this reason, the objective of this study is to determine the relationship between economic growth and occupational accidents.

Literature review

Conceptualisation of economic growth

The concept of economic growth can be defined as 'the quantitative increase or expansion of income and the value of final goods and services produced within the economic system over a given period' (Enríquez-Pérez 2016), typically proxied by real Gross Domestic Product (GDP) or GDP per capita, over a given period. As noted by Jiménez (2011), it is a topic that generates significant interest within economics because of its impact on societal well-being. From this same perspective, Julca-Vegas (2016) and Loayza and Soto (2002) agree that economic growth is a measure of a country's population's well-being, encompassing the sustained increase in income. While growth is a prerequisite for development, it does not automatically yield improvements in well-being or equity; inclusive growth is necessary for development to translate into broader social gains (Mankiw 2021; Todaro & Smith 2015). The macroeconomic literature identifies a set of core growth models (Chirinos 2007; Loayza & Soto 2002):

- In 1956, the Solow-Swan model examined economic growth as a medium-term outcome resulting from the accumulation of factors and as a long-term outcome of technological progress. This model conceives innovation as an exogenous source, which constitutes its primary theoretical weakness.
- In the 1960s, the Ramsey-Cass-Koopmans model refined the Solow-Swan model. This new model established an optimal consumption pattern along a growth path; however, diminishing returns eventually led the economy to a state where growth ceased.
- In 1963, Kaldor pointed out that, over time, GDP per capita increases (this growth does not decline), and likewise, systematic declines in the rate of return on capital are not observed.
- In 1986, Romer introduced a model in which long-term economic growth occurs not because of exogenous technological progress but because capital accumulation generates externalities that offset diminishing returns.
- In 1988, Robert Lucas introduced a model in which human capital plays a fundamental role in sustaining economic growth and preventing diminishing returns on the accumulation of physical capital.
- In 1991, Robert Barro initiated what is now known as the 'empirical literature on economic growth'. Barro conducted the first study analysing the determinants of growth using national accounts data from over 130 countries, compiled between 1950 and 1988 by Heston and Summers. These data were comparable, as the macroeconomic aggregates were expressed in a single currency: US dollars (Chirinos 2007).

These models are relevant to occupational safety because they shape patterns of capital investment, labour market composition and technological innovation, all of which directly influence workplace safety standards and accident risks.

Conceptualisation of occupational accidents

Starting from the premise that 'all work is hazardous', no occupation can be deemed entirely safe. However, the necessity of working remains (Gómez-Pineda 2014), which is why occupational safety and health have become paramount.

The initial conceptualisation of accidents, according to Aristotle's philosophy, regarded them as occurrences without an inherent cause, not fitting within a broader metaphysical framework and from which no significant knowledge could

be derived (Loimer & Guamieri 2011). This perception of accidents persisted until, between the 16th and 18th centuries, accidents were redefined under the premise that they provided insight into hidden knowledge, either as manifestations of divine will or as fortuitous revelations of natural processes. The providential understanding of accidents remained culturally dominant until the late 18th century, when the emergence of probabilistic thinking and the practice of first aid began to erode its legitimacy (Potter 1997).

By the late 19th and early 20th centuries, accidents were increasingly studied to understand how to prevent future occurrences (Vieira 2013). This shift marked a turning point in accident theory, unifying its conceptual development across four centuries. The modern understanding of an accident centres on the idea that it is an unintended and unforeseen result of a preceding cause, which can be identified and understood. It is perceived as a phenomenon that can only be comprehended through the sequential order of preceding events, with its revelation occurring solely through the construction of a narrative (Vieira 2013).

Over the centuries, the evolving epistemological assumptions inherent in the concept of accidents align with the three periods of knowledge history identified by Auguste Comte: theological, metaphysical and positive (Ñaupas-Paitán et al. 2018). However, Karl Popper's realist approach argues that 'descriptions of the world provided by research maintain a high degree of correspondence with reality'.

Definitions of occupational accidents agree that they cause harm to individuals in the form of injuries, illnesses, or death. However, other definitions also include other types of damage, such as damage to property, processes and the environment. From an occupational safety and health perspective, the primary goal is to preserve workers' well-being. In this sense, the following definition of occupational accident is proposed: an unplanned event, causally related to work activity, that results in injury to one or more workers, including fatal incidents.

From this perspective, occupational accidents are not isolated events but outcomes shaped by a combination of workplace conditions, workforce characteristics and macroeconomic contexts.

Economic growth and occupational accidents

Research on occupational accidents has primarily focused on environmental and organisational factors, such as job design, working conditions, work organisation and the physical characteristics of the workplace (Christian et al. 2009; Lingard & Rowlinson 2005). Likewise, the role of personal factors – such as monthly income, age, gender, motivation and work experience – has been widely acknowledged (Gyekye 2005). However, the impact of macroeconomic variables, including economic growth, national income, unemployment and socio-cultural development, has received comparatively little attention in this field (Boone & Van Ours 2006). To the best of current knowledge, no studies have systematically examined the long-term effect of economic growth on the incidence of occupational accidents. Investigating this relationship could be valuable for anticipating accident rates and related indicators and for providing empirical evidence to support the design and implementation of more effective preventive strategies in occupational safety and health.

Methods

As part of the systematic review of the literature, systematic mapping was included. Systematic mapping is a research technique that ensures a structured review process and minimises errors that could lead to inaccurate conclusions (Petersen et al. 2008). The methodology followed these steps: definition of the research question, strategies for searching for primary studies, inclusion and exclusion criteria, data extraction and mapping of studies, determination of the classification scheme and synthesis of the evidence.

Definition of the research question

The purpose of this systematic mapping was established as a research question: what is the relationship between economic growth and occupational accidents? To this end, we sought to identify and classify the studies on this topic in the period between 2000 and 2020.

Definition of search strategies for primary studies

The search for primary studies consists of two steps:

- The search strategy is defined considering the most relevant terms related to the topic under study.
- The relevant electronic databases are selected to carry out the search.

To design the search strategy, keywords were identified based on the research questions and the consultation of relevant documents. Table 1 presents the main keywords and related terms.

To elaborate on the final search strategy, categories T1 and T2 were combined with the Boolean operator AND, and related terms within each category were combined with the Boolean operator OR, as shown in Box 1:

The search was conducted using the electronic databases subscribed to by the Virtual Library of the National Council of Science, Technology and Technological Innovation of Peru – CONCYTEC for RENACYT users: EBSCOhost, DynaMed, IEEE Xplore, IOP, SAGE, Scopus, ScienceDirect, Taylor & Francis and Wiley.

BOX 1: Related terms in categories T1 and T2 combined with the Boolean operator OR.

('Economic Growth' OR 'Economic Development' OR 'Economic Situation' OR 'Business Cycle' OR 'Political Economy' OR 'Economic Cycle' OR 'Economic Crisis') AND ('Occupational Accidents' OR 'Workplace Accidents' OR 'Labour Accidents' OR 'Occupational Injuries' OR 'Workplace Injuries' OR 'Labour Injuries')

It should be noted that the search strategy was adapted to the parameters of each database consulted, obtaining a total of 879 preliminary publications:

- The search was carried out in all the fields of the databases, except for EBSCOhost, SAGE, Scopus and Taylor & Francis, because it was possible to narrow down the fields with the advanced search option.
- Because of the limited number of search words in the ScienceDirect database, the search strategy was partially modified.

Definition of inclusion and exclusion criteria

The following inclusion and exclusion criteria were applied:

- Inclusion Criteria:
  I1. Original articles or research in indexed journals
  I2. Articles published between 2000 and 2020.
- Exclusion Criteria:
  E1. Articles that are not explicitly linked to the relationship between economic growth and occupational accidents.
  E2. Qualitative research articles.
  E3. Articles lacking information that responds to the research questions.

Data extraction and study mapping

The selected articles were reviewed and analysed in order to extract and record their data in a matrix (Revelo-Sánchez et al. 2018; Riaño-Casallas & Palencia-Sánchez 2016). The general data of the articles and the specific data linked to the questions of the present investigation are presented below:

- General Data: Year of publication, author, title and area of knowledge.
- Specific Data: Countries studied, economic growth indicators, occupational accident indicators, data analysis techniques and conclusions.

Determination of the classification scheme

A literature map is designed to summarise and classify the literature (Creswell & Creswell 2022). The literature map graphically represents a visual summary of research that has been conducted by other researchers. A hierarchical structure with a left-to-right presentation was used for the conceptual design.

Synthesis of the evidence

Once the data from the selected studies have been extracted, the evidence is synthesised. Given that the studies vary in terms of their designs, populations, indicators and results (known as heterogeneity), a narrative synthesis was used. The findings were grouped and compared according to pre-established criteria, such as geographical context, economic sector, severity of accidents and macroeconomic indicators used.

Ethical considerations

An application for full ethical approval was made to the Postgraduate Unit of the Faculty of Industrial Engineering, and ethics consent was received on 28 December 2020. The ethical clearance number is 470-UPG-FII-2020.

Results

The results of the literature review, which sought to provide an overview of the relationship between economic growth and workplace accidents, are presented.

Figure 1 illustrates the execution of the steps described in the previous sections using a Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow diagram. The search was conducted in the selected databases, yielding 879 articles. The inclusion criteria were then applied, reducing the number to 530 by retaining only original articles (I1) and those published between 2000 and 2020 (I2) and by removing duplicates across databases, keeping a single copy of each article. Subsequently, the

TABLE 1: Keywords and related terms.

Category	Keyword	Related terms
T1	Economic growth	Economic development Economic situation Business cycle Political economy Economic cycle Economic crisis
T2	Occupational accidents	Workplace accidents Labour accidents Occupational injuries Workplace injuries Labour injuries

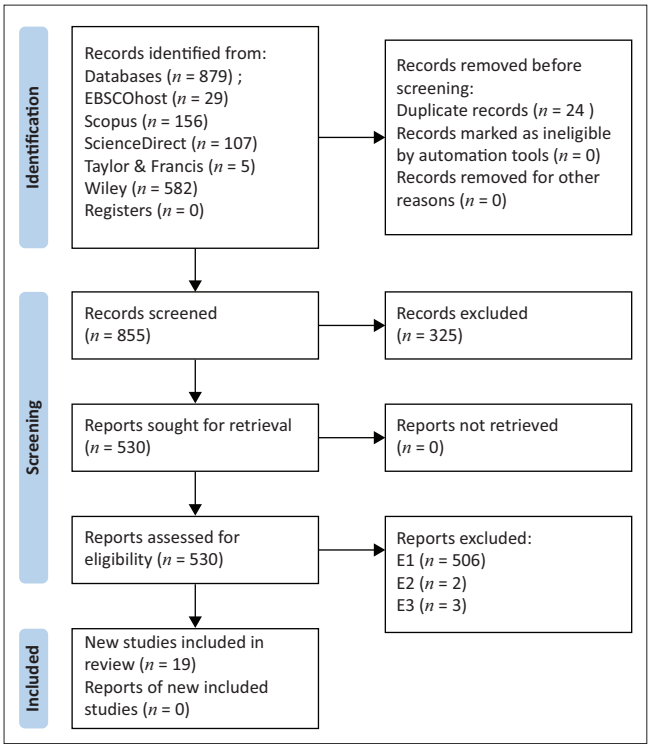

FIGURE 1: PRISMA 2020 flow diagram applied in the literature review.

exclusion criteria were applied: (E1) articles that do not explicitly address the relationship between economic growth and occupational accident rates; (E2) qualitative studies; and (E3) articles lacking relevant information to answer the research questions. Two cases were identified under criterion E3.

Table 2 presents the list of 19 articles that were analysed to answer the research question.

Figure 2 shows the spatial distribution of the articles by country studied, showing that this type of study was conducted in:

- Eight high-income countries (Austria, Denmark, Italy, Poland, South Korea, Spain, the United Kingdom and the United States of America); two middle-income countries (China and Turkey) and one unclassified territory (Taiwan).
- Ten developed countries (Austria, China, Denmark, Italy, Poland, South Korea, Spain, Taiwan, the United Kingdom and the United States of America) and one developing country (Turkey). A special case is Taiwan, which is not a sovereign country but a territory at the level of a developed country.
- Six European countries (Austria, Denmark, Spain, Italy, Poland and the United Kingdom), four Asian countries (China, South Korea, Taiwan and Turkey) and one American country (the United States of America).

The studies used publicly available data covering various time periods (time series):

- In Spain, three studies were developed, with national data, evaluating the following periods: 1991–2013 (Contreras-Ovejero, Manzanedo del Campo & Herrero-Cosío 2018), 1994–2014 (Fernández-Muñiz, Montes-Peón & Vázquez-Ordás 2018), y 2007–2013 (Contreras, Manzanedo & Herrero 2019).
- In China, two studies were developed. National data were analysed for the period 1953–2008 (Song et al. 2011), whilst in the period 2007–2011, data from 346 counties in Central China were analysed (Wei et al. 2016).
- In Denmark, two studies were developed with data from the construction sector, which evaluated the following periods: 1980–2010 (Lander, Nielsen & Lauritsen 2016) y 1984–2010 (Nielsen, Lander & Lauritsen 2015).
- Two studies were conducted in the United States. In the period 1976–2007, national data and data from the agriculture, mining, construction, manufacturing and commerce sectors were analysed (Asfaw, Pana-Cryan & Rosa 2011). In the period 1980–1995, data from 50 US states were analysed (Loomis et al. 2009).
- In the United Kingdom, two studies were developed, with national data, which evaluated the periods: 1971–2007 (Mouza & Targoutzidis 2012) and 1986–2004 (Davies, Jones & Nuñez 2009).

TABLE 2: Articles selected for review.

Year	Authors	Purpose of the study
2020	Kim and Park	Examine how major economic indicators representing economic fluctuations are related to occupational accidents
2020	Gümüş and Gülsün	Analyse the state of occupational safety and health and examine its relationship with some socioeconomic factors
2019	Kahraman et al.	Examine the relationship between fatal occupational accidents and the independent variables that are national income and employment rate in 18 developed and developing countries and one region between 2006 and 2015
2019	Contreras et al.	Examine the relationship between the economic crisis and occupational accidents
2018	Ovejero et al.	Determine whether there is any relationship between economic cycles and occupational accidents
2018	Chang et al.	Relate major and minor occupational injuries to various macroeconomic variables
2018	Farina et al.	Examine possible correlations between injury rates and major macroeconomic factors
2018	Fernández-Muñiz et al.	Determine to what extent the economic cycle affects the number of occupational accidents
2018	Łyszczarz and Nojszewska	Investigate the relationship between the economic situation and the occupational accident rate
2017	Çolak and Palaz	Examine the relationship between occupational fatalities and economic development
2016	Lander et al.	Analyse the impact of the economic cycle on occupational injuries according to these working conditions
2016	Wei et al.	Explore the influence of socioeconomic inequalities on the job security situation
2015	Nielsen et al.	Examine and compare the relationship between macroeconomic and industry-specific business cycle indicators and work-related injuries
2012	Mouza and Targoutzidis	Investigate the effect of the economic cycle on the occupational accident rate
2011	Song et al.	Explore the longitudinal relativity between economic development and fatal occupational accidents
2011	Asfaw et al.	Explore the association between the business cycle and the incidence of workplace injuries to identify cyclically sensitive industries and the relative contribution of physical capital and labour utilisation within industries
2009	Loomis et al.	Investigate the extent to which political economy, including the relative power of organised labour, predicts fatal occupational injury rates
2009	Davies et al.	Update the relatively limited evidence on the effects of the business cycle on workplace injury rates
2007	Barth et al.	Evaluate whether there is a relationship between Gross Domestic Product and the incidence of occupational accidents

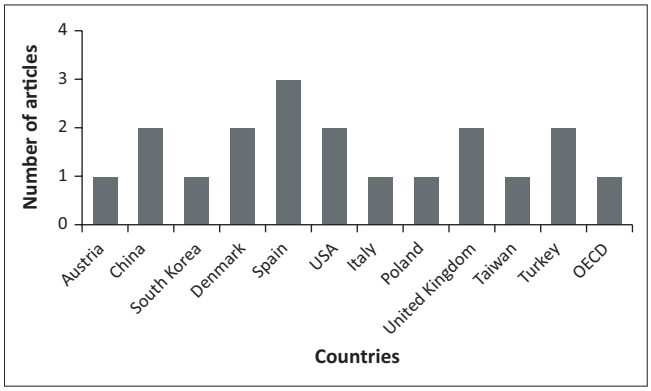

FIGURE 2: Total number of articles studied per country.

- In Turkey, two studies were developed, with national data, evaluating the periods: 1998–2014 (Gümüş & Gülsün 2020) and 1980–2012 (Çolak & Palaz 2017).
- In Austria, one study was developed, with national data, which evaluated the period 1955–2004 (Barth et al. 2007).
- In South Korea, one study was developed, with national data, which evaluated the period 2007–2017 (Kim & Park 2020).
- In Italy, one study was developed, with data from the manufacturing sector, which evaluated the period 1994–2012 (Farina et al. 2018).
- In Poland, one study was developed, with data from 66 subregions, in the period 2002–2014 (Łyszczarz & Nojszewska 2017).
- In Taiwan, one study was developed, with data from the manufacturing, construction, commerce and accommodation and food service sectors in the period 2002–2014 (Chang et al. 2018).
- One study was conducted that analysed, in a joint form, data from 18 developed and developing countries and one region (Hong Kong), attached to the Organisation for Economic Co-operation and Development (OECD), in the period 2006–2015 (Kahraman et al. 2019).

Prior to determining the relationship between economic growth and occupational accidents, it was necessary to identify and classify the indicators used in the respective statistical analyses (Figure 3).

For economic growth, 56 indicators were identified and classified into four dimensions:

- Amongst the 15 macroeconomic indicators, the most commonly used were GDP, GDP per capita, GDP growth rate and the Production Index.
- Amongst the 31 employment indicators, the most commonly used was the unemployment rate.
- Amongst the five social indicators, none was used in more than one study; however, it is worth mentioning that the Human Development Index (HDI) and the Human Capital Index (HCI) are related, because, of the three components of the HDI, both the health index and the education index are used to determine the HCI.
- Amongst the six infrastructure indicators, the most commonly used was the housing construction permit.

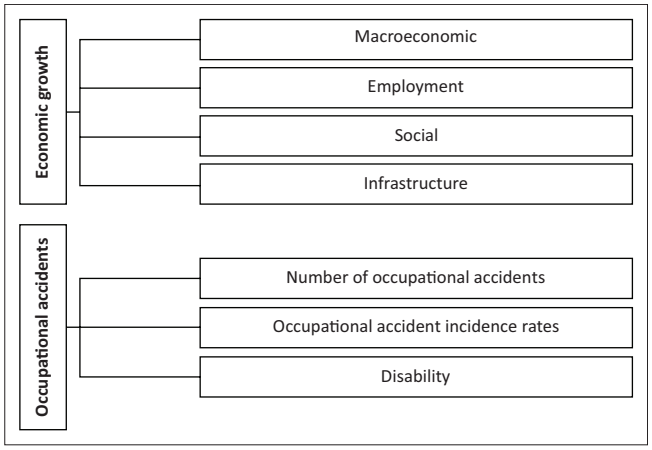

FIGURE 3: Classification of the dimensions of economic growth and occupational accidents indicators.

For occupational accidents, 15 indicators were identified and classified into three dimensions:

- Amongst the seven indicators of the number of occupational accidents (absolute values), the most commonly used was the number of fatal accidents.
- Amongst the five indicators relating to occupational accident incidence rates (indices), the most commonly used was the total incidence rate.
- Amongst the three indicators related to disability, none was used in more than one study.

Across the reviewed studies, GDP growth rate, GDP per capita and unemployment rate emerged as the most consistent macroeconomic predictors of occupational accident trends, while the number of fatal accidents and total incidence rate were the most commonly used safety indicators.

To relate the indicators of economic growth and occupational accidents, quantitative studies were applied using eight types of methodology, the most used being multiple linear regression (four studies), followed by the autoregressive model, neural networks, panel data regression and simple linear regression (three studies each).

A critical comparison and interpretation across studies

Research on the relationship between economic growth and occupational accidents has generated diverse and sometimes contradictory results, reflecting the complexity of the phenomenon and the influence of multiple factors, including the definition of an accident, the severity of the injury, the economic indicators used, and the geographical and sectoral context.

Pro-cyclical relationship (more accidents during economic growth)

Numerous studies find a pro-cyclical relationship, meaning that the incidence of occupational accidents tends to increase during periods of economic expansion and decrease during recessions (Asfaw et al. 2011; Chang et al. 2018; Çolak & Palaz 2017; Davies et al. 2009; Farina et al. 2018; Fernández-Muñiz et al. 2018; Kim & Park 2020; Kossoris 1938; Łyszczarz & Nojszewska 2017):

- Kossoris (1938) pioneered in finding a pro-cyclical relationship between reported accidents and employment in the manufacturing sector in the United States. Subsequent research in the UK (1986–2005) also confirmed a pro-cyclical behaviour of minor injuries in general and more acute effects in the construction and manufacturing sectors (Davies et al. 2009). Similarly, in the United States (1976–2007), pro-cyclical associations

were observed between business cycle indicators (such as real GDP, the unemployment rate and the index of industrial production) and the incidence of occupational injuries in mining, construction and manufacturing (Asfaw et al. 2011).

- In Spain (1994–2014), a strong pro-cyclical association was found. The economic recovery from 2014 onwards led to a further increase in the accident rate, reversing a downward trend observed since 2001. It was observed that each percentage point change in the GDP growth rate in Spain caused an eight-point change in the standardised incidence rate (Fernández-Muñiz et al. 2018). This suggests that economic growth in Spain has led to a high level of occupational accidents, indicating a weakness in its prevention system (Fernández-Muñiz et al. 2018).
- In Korea (2007–2017), the frequency of occupational accidents showed a statistically significant relationship with economic indicators. The monthly number of occupational injury and illness cases, and fatal occupational injuries, were related to manufacturing capacity utilisation, differences in the production rate of the service sector and the start of building construction (Kim & Park 2020). A 1% increase in the rate of manufacturing capacity utilisation resulted in an increase of about 45 injury or illness fatalities (Kim & Park 2020).
- In Poland (2002–2014), occupational accidents showed a pro-cyclical behaviour, with more accidents during economic expansions. This relationship was strongest for accident rates amongst men and total rates (Łyszczarz & Nojszewska 2017). A 1% growth in GDP per capita or average wage was associated with slightly more than a 0.4% increase in the occupational accident rate (Łyszczarz & Nojszewska 2017).
- In China (1953–2008), after 1979, the economic cycle was an important indicator of occupational accidents. Economic boom could drive the increase of occupational fatalities in the short term, and economic depression could promote their decrease (Song et al. 2011). In Central China (2010), occupational fatalities were found to be positively related to secondary industry value added, scalable industrial production value and infrastructure investment (Wei et al. 2016).
- In Italy (1994–2012), injury rates were significantly associated with business cycle indicators in the manufacturing sector. For each percentage point increase in real GDP growth, total and serious injury rates increased by 1% (Farina et al. 2018).
- In the UK (1971–2007), an elastic and positive relationship between hours worked and fatal injuries was observed (Mouza & Targoutzidis 2012). A 10% increase in hours worked on average per year could increase fatal injuries by 22.85% over the same period (Mouza & Targoutzidis 2012).

Counter-cyclical or inelastic relationship (fewer accidents during economic growth)

Some studies have found a counter-cyclical or inelastic relationship, especially for serious or fatal injuries, or in the long run (Barth et al. 2007; Çolak & Palaz 2017; Mouza & Targoutzidis 2012):

- In Austria (1955–2004), an economic growth measured by real GDP was associated with a decrease in fatal and non-fatal injury rates (Asfaw et al. 2011; Barth et al. 2007). A billion increase in GDP reduced injuries per million employees by 1437 cases (Asfaw et al. 2011).
- In the UK (1971–2007), the relationship of GDP per capita was controversial and inelastic (negative), and the unemployment rate also showed an inelastic (positive) relationship with fatal injuries (Mouza & Targoutzidis 2012). A 10% increase in GDP per capita could decrease fatal injuries by approximately 2.3% with a 1-year lag, while a 10% increase in the unemployment rate would decrease fatal injuries by 1.85% with a 1-year lag (Mouza & Targoutzidis 2012).
- In Turkey (1980–2012), in the long run, a negative relationship was found between GDP per capita and fatal occupational accidents (Çolak & Palaz 2017). That is, an increase in GDP, as a measure of welfare, and increased investment in new technologies would reduce occupational accidents (Çolak & Palaz 2017).
- Across multiple countries, a study covering 18 countries and one region (2006–2015) found that while a 1% increase in national income reduced the fatal accident rate by 1.19%, a 1% increase in the employment rate resulted in an increase of approximately 4.19% in the fatal accident rate (Kahraman et al. 2019).

Differences by severity and industry sector

Minor injuries are consistently observed to be more sensitive to the business cycle and tend to be pro-cyclical (Asfaw et al. 2011; Boone & Van Ours 2006; Chang et al. 2018; Davies et al. 2009). Serious or fatal injuries, on the other hand, show a less clear relationship, often counter-cyclical, inelastic or not significant (Asfaw et al. 2011; Boone & Van Ours 2006; Chang et al. 2018; Davies et al. 2009; Lander et al. 2016).

The construction, manufacturing and mining sectors are consistently identified as the most sensitive to economic fluctuations and show pro-cyclical accident rates (Asfaw et al. 2011; Chang et al. 2018; Davies et al. 2009; Farina et al. 2018; Fernández-Muñiz et al. 2018; Lander et al. 2016). This may be because firms in construction are more likely to rely on temporary workers and experience disorganisation on site (Davies et al. 2009). The agriculture and trade sectors, in contrast, are less sensitive to the aggregate business cycle (Asfaw et al. 2011; Chang et al. 2018; Fernández-Muñiz et al. 2018).

Underreporting hypothesis and its impact

The underreporting hypothesis is a key point of controversy. Some researchers argue that the observed pro-cyclical relationship, especially for minor injuries, could be a spurious phenomenon. They propose that in times of economic downturn, workers are afraid of losing their jobs and therefore report fewer minor accidents (Asfaw et al. 2011; Boone & Van Ours 2006; Çolak & Palaz 2017; Davies et al. 2009). In contrast, in expansion stages, workers are more

willing to report accidents because of greater job security or bargaining power (Davies et al. 2009). Fatal accident data are considered more reliable because they are less susceptible to underreporting, and thus their relationship with labour market indicators is sometimes insignificant or counter-cyclical (Barth et al. 2007; Boone & Van Ours 2006; Davies et al. 2009). However, other studies suggest that even fatal accidents may be pro-cyclical or that the change in reporting behaviour does not fully explain the relationship (Fernández-Muñiz et al. 2018; Lander et al. 2016; Song et al. 2011).

In summary, while the evidence suggests a strong correlation between economic growth and occupational accidents, the nature of this relationship (pro-cyclical, counter-cyclical or inelastic) depends largely on the severity of the injury, the industrial sector, the specific economic indicators and the time horizon (short or long term) considered in the analysis (Çolak & Palaz 2017; Mouza & Targoutzidis 2012).

Discussion

The question of the relationship between economic growth and occupational accidents reveals a complex and multifaceted interconnection that goes beyond a simple linear relationship. The results presented, although varied, allow us to identify underlying patterns and mechanisms that explain these dynamics, integrating empirical observations with economic and labour theories.

The duality of correlation: Pro-cyclical versus counter-cyclical

The empirical evidence is not unanimous, suggesting that the correlation between economic growth and occupational accidents is not inherently unidirectional but depends on moderating factors.

There is a general consensus that minor accidents or non-fatal injuries tend to show pro-cyclical behaviour (Asfaw et al. 2011; Boone & Van Ours 2006; Chang et al. 2018; Davies et al. 2009). This is observed in a number of economies, including the United States, the United Kingdom, Korea, Poland, Spain, China and Italy (Asfaw et al. 2011; Chang et al. 2018; Davies et al. 2009; Farina et al. 2018; Fernández-Muñiz et al. 2018; Kim & Park 2020; Łyszczarz & Nojszewska 2017). This pattern is particularly pronounced in high-risk sectors such as manufacturing, construction and mining (Asfaw et al. 2011; Chang et al. 2018; Davies et al. 2009; Farina et al. 2018; Fernández-Muñiz et al. 2018; Lander et al. 2016). In the short run, even fatalities may follow a pro-cyclical pattern in economies such as Turkey (Çolak & Palaz 2017) or China (Song et al. 2011).

On the other hand, the relationship becomes more complex or even counter-cyclical for severe and fatal injuries or when analysing the long term (Barth et al. 2007; Çolak & Palaz 2017; Mouza & Targoutzidis 2012). Developed countries such as Austria show a decrease in injury rates with GDP growth (Asfaw et al. 2011; Barth et al. 2007), and a multi-geographic analysis reveals that national income can reduce fatal accidents, while employment rate increases them (Kahraman et al. 2019). In the long run, in Turkey, an increase in GDP is associated with a decrease in fatal crashes (Çolak & Palaz 2017). This disparity suggests that different mechanisms operate depending on the severity of the accident and the time horizon.

This aligns with Kossoris's (1938) early proposition that economic booms can increase accident risks through workforce changes and supports the notion that sustained growth enables investment in safer technologies and stronger regulatory frameworks.

Mechanisms driving the correlation (possible causes)

Theories proposed by Kossoris (1938) and Mouza and Targoutzidis (2012, cited by Nichols 1986, 2009), along with recent findings, offer explanations for how economic growth influences occupational safety and health:

- Workforce Composition (Pro-cyclical): during economic booms, increased demand for labour leads to the hiring of new, less skilled or temporary workers (Chang et al. 2018; Çolak & Palaz 2017; Davies et al. 2009; Farina et al. 2018; Kossoris 1938; Mouza & Targoutzidis 2012). These groups are inherently more accident-prone because of their unfamiliarity with the environment, procedures and machinery (Chang et al. 2018; Farina et al. 2018; Fernández-Muñiz et al. 2018). Firms often resort to temporary employment and adjust working hours before hiring permanent staff, given the lower 'adjustment cost' (Chang et al. 2018). In recessions, layoffs often affect workers with less seniority first, leaving a more experienced and thus less accident-prone workforce (Çolak & Palaz 2017; Fernández-Muñiz et al. 2018).
- Working Conditions and Pace of Work (Pro-cyclical): To meet increasing demand during expansions, companies can accelerate the pace of production, leading to longer working hours, overtime and less time for breaks (Asfaw et al. 2011; Chang et al. 2018; Davies et al. 2009; Farina et al. 2018; Fernández-Muñiz et al. 2018; Łyszczarz & Nojszewska 2017; Mouza & Targoutzidis 2012). Accumulated fatigue and stress can decrease safety awareness and increase operational errors (Asfaw et al. 2011; Chang et al. 2018). In this context, safety standards may be overlooked (Asfaw et al. 2011; Farina et al. 2018). The economic boom may drive the use of older or less safe machinery to meet extra demand or reduce the time available for proper maintenance (Çolak & Palaz 2017; Mouza & Targoutzidis 2012).
- Reporting Behaviour (Apparent Pro-cyclical): A common explanation for the pro-cyclical pattern of minor accidents is underreporting during recessions (Asfaw et al. 2011; Boone & Van Ours 2006; Çolak & Palaz 2017; Davies et al. 2009). Workers may be afraid to report minor injuries for fear of being fired, as job security is low (Çolak & Palaz

2017; Davies et al. 2009). In contrast, during expansions, with greater job security and bargaining power, workers may feel more confident to report accidents or may even have incentives to do so, as labour compensation may be higher than unemployment benefits (Asfaw et al. 2011; Davies et al. 2009). This is a hypothesis that some authors suggest could generate a 'spurious' pro-cyclical pattern for reported minor injuries (Davies et al. 2009).

- Investment in Safety and Economic Development (Counter-cyclica or Negative): Growing economies and wealthier countries have more resources to invest in safer technologies, modern equipment, automation and occupational health and safety measures (Barth et al. 2007; Çolak & Palaz 2017). This investment, which is often seen as a long-term effect, can reduce accident rates regardless of the short-term economic cycle (Çolak & Palaz 2017). General economic development can also be accompanied by better working conditions, better protection of workers' rights and increased awareness of occupational safety and health, which in the long run reduces accident rates (Çolak & Palaz 2017). During crises, only more experienced workers with permanent contracts tend to keep their jobs, which reduces the accident rate because of a more skilled workforce (Çolak & Palaz 2017; Fernández-Muñiz et al. 2018).

Implications and challenges for public policy

The complexity of this relationship has direct implications for the design of occupational safety and health policies:

- Effective occupational safety and health policy must go beyond aggregate trends and consider differences by industry sector, accident severity and type of economic indicator (Asfaw et al. 2011; Chang et al. 2018; Davies et al. 2009; Łyszczarz & Nojszewska 2017). High-risk sectors such as construction and manufacturing, which are highly sensitive to cycles, require special attention during booms (Asfaw et al. 2011; Davies et al. 2009; Farina et al. 2018).
- During expansion periods, it is crucial to implement intensive training programmes and adequate supervision for new and temporary workers (Chang et al. 2018; Davies et al. 2009; Łyszczarz & Nojszewska 2017).
- Reasonable limits must be set on working hours, adequate breaks must be ensured, and the intensity of the pace of production must be controlled, especially during peak demands, to mitigate fatigue and stress (Chang et al. 2018, Davies et al. 2009; Łyszczarz & Nojszewska 2017).
- It is essential to create an environment where workers are not afraid to report accidents or work-related illnesses, regardless of economic status. This involves combating discrimination towards injured workers and ensuring fair compensation systems (Łyszczarz & Nojszewska 2017).
- Policies should encourage continued investment in safety, new technologies and improved working conditions, even during recessions, to ensure a long-term decline in serious and fatal accidents (Barth et al. 2007; Çolak & Palaz 2017).
- Regulators should adjust the frequency and stringency of safety inspections according to the phases of the business cycle, intensifying them during economic booms (Chang et al. 2018). The marked sensitivity of the accident rate to the economic cycle in Spain, in contrast to Germany, suggests that its prevention system is less robust (Fernández-Muñiz et al. 2018).

In summary, the discussion underlines that the relationship between economic growth and occupational accidents is a dynamic phenomenon, influenced by the interaction of economic, labour and social factors. Understanding these mechanisms is vital to develop accident prevention strategies that are effective in different economic contexts.

Conclusion

The results of the literature review confirm that yes, there is a relationship between economic growth and occupational accidents, but its nature and magnitude are complex and multifaceted, varying significantly according to the context and severity of the accident.

The most consistent evidence points to a predominantly pro-cyclical relationship for minor work injuries and for short-term analyses, particularly in high-risk sectors such as manufacturing, construction and mining. This is mainly attributed to mechanisms such as the addition of new or temporary workers with less experience, increased work intensity, overtime and employee fatigue, and reduced attention to safety measures during economic booms to meet increasing demand. In addition, a possible bias in accident reporting, where workers report more minor injuries during booms (for greater job security) and fewer during recessions (for fear of losing their jobs), may contribute to this apparent pro-cyclicality.

On the other hand, the correlation becomes more inelastic or even counter-cyclical for severe and fatal injuries or in the long-term analysis. These dynamics suggest that, with sustained economic development, countries and firms may invest more in safety technologies, training and better working conditions, leading to an overall reduction in serious accidents over time. The 'natural selection' of the labour market during recessions, which retains more experienced workers, can also contribute to a reduction in accident rates.

In summary, while economic growth is often associated with an increase in occupational accidents in the short term and in certain categories, the relationship is complex and non-linear. Occupational safety and health policies need to adapt to these dynamics, focusing on active prevention during economic booms, especially in high-risk sectors, and addressing potential problems of underreporting in downturns to get a more accurate picture and mitigate risks effectively.

Given the sectoral and severity-specific variations identified, occupational safety strategies should be tailored to economic

conditions. Regulators should intensify inspections and training during economic booms, maintain investment in safety technologies during recessions and address underreporting across all phases of the business cycle to ensure accurate monitoring and effective prevention.

Acknowledgements

This article is partially based on the P.C.G-F.'s thesis entitled *'La relación del crecimiento económico sobre los accidentes de trabajo – caso Peruano* [The Relationship between Economic Growth and Occupational Accidents – Peruvian Case]' towards the degree of Doctor in Industrial Engineering in the Faculty of Industrial Engineering, Universidad Nacional Mayor de San Marcos, Peru, on 21 December 2023, with supervisor Alfonso Ramón Chung Pinzás. The supervisor was not involved in the preparation of this manuscript and was not listed as a co-author. It can be found here: https://hdl.handle.net/20.500.12672/20527.

This article benefited from the use of ChatGPT5 and DeepL for grammar refinement and improving readability. The content was reviewed and edited by the author, who takes full responsibility for its accuracy.

Competing interests

The author declares that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Author's contribution

P.C.G-F. is the sole author of this research article.

Funding information

This research was supported by Universidad Nacional Mayor de San Marcos and the Postgraduate Unit of the Faculty of Industrial Engineering with Grant number 470-UPG-FII-2020.

Data availability

The data that support the findings of this study are available from the corresponding author, P.C.G-F., upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the author and are the product of professional research. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency or that of the publisher. The author is responsible for this article's results, findings and content.

References

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. https://doi.org/10.1016/j.jsr.2010.10.008

Barth, A., Winker, R., Ponocny-Seliger, E. & Sögner, L., 2007, 'Economic growth and the incidence of occupational injuries in Austria', *Wiener Klinische Wochenschrift* 119(5–6), 158–163. https://doi.org/10.1007/s00508-006-0726-7

Boone, J. & Van Ours, J.C., 2006, 'Are recessions good for workplace safety?', *Journal of Health Economics* 25(6), 1069–1093. https://doi.org/10.1016/j.jhealeco.2006.03.002

Chang, D.S., Chen, Y. & Tsai, Y.C., 2018, 'How injury incidence is associated with business cycles? Empirical evidence from Taiwan', *Safety Science* 110, 235–248. https://doi.org/10.1016/j.ssci.2018.08.014

Chirinos, R., 2007, *Determinantes del crecimiento económico: Una revisión de la literatura existente y estimaciones para el período 1960–2000* [*Determinants of economic growth: A review of the existing literature and estimates for the period 1960–2000*], Central Reserve Bank of Peru, Lima.

Christian, M.S., Bradley, J.C., Wallace, J.C. & Burke, M.J., 2009, 'Workplace safety: A meta-analysis of the roles of person and situation factors', *Journal of Applied Psychology* 94(5), 1103–1127. https://doi.org/10.1037/a0016172

Çolak, O. & Palaz, S., 2017, 'The relationship between economic development and fatal occupational accidents: Evidence from Turkey', *Scientific Annals of Economics and Business* 64(1), 19–31. https://doi.org/10.1515/saeb-2017-0002

Contreras-Ovejero, S., Manzanedo del Campo, M.Á. & Herrero-Cosío, Á., 2018, 'Crisis económicas y su influencia en la siniestralidad laboral' [Economic crises and their influence on workplace accidents], *Dirección y Organización* 65, 5–19. https://doi.org/10.37610/dyo.v0i65.525

Contreras, S., Manzanedo, M. & Herrero, Á., 2019, 'A hybrid neural system to study the interplay between economic crisis and workplace accidents in Spain', *Journal of Universal Computer Science* 25(6), 667–682.

Creswell, J.W. & Creswell, J.D., 2022, *Research design: Qualitative, quantitative, and mixed methods approaches*, 6th edn., SAGE, Thousand Oaks, CA.

Davies, R., Jones, P. & Nuñez, I., 2009, 'The impact of the business cycle on occupational injuries in the UK', *Social Science & Medicine* 69(2), 178–182. https://doi.org/10.1016/j.socscimed.2009.04.033

Enríquez-Pérez, I., 2016, 'Las teorías del crecimiento económico: Notas críticas para incursionar en un debate inconcluso' [Theories of economic growth: Critical notes to delve into an unfinished debate], *Revista Latinoamericana de Desarrollo Económico* 14(25), 73–126. https://doi.org/10.35319/lajed.20162564

Farina, E., Giraudo, M., Costa, G. & Bena, A., 2018, 'Injury rates and economic cycles in the Italian manufacturing sector', *Occupational Medicine* 68(7), 459–463. https://doi.org/10.1093/occmed/kqy102

Fernández-Muñiz, B., Montes-Peón, J.M. & Vázquez-Ordás, C.J., 2018, 'Occupational accidents and the economic cycle in Spain 1994–2014', *Safety Science* 106, 273–284. https://doi.org/10.1016/j.ssci.2016.02.029

Gómez-Pineda, F.H., 2014, 'Reflexión ética: La relación conflictiva entre salud y trabajo: La relación conflictiva entre salud ytrabajo' [Ethical perspective: The troubled relationship between health and work], *Revista Colombiana de Salud Ocupacional* 4(4), 5–11. https://doi.org/10.18041/2322-634X/rcso.4.2014.4959

Gordon, J.E., 1949, 'The epidemiology of accidents', *American Journal of Public Health* 39(4), 504–515. https://doi.org/10.2105/AJPH.39.4.504

Gümüş, R. & Gülsün, Z., 2020, 'Occupational health and safety indicators of Turkey and their relationships with social and economic development factors between 1998 and 2014', *International Journal of Healthcare Management* 13(2), 99–107. https://doi.org/10.1080/20479700.2017.1308669

Gyekye, S.A., 2005, 'Workers' perceptions of workplace safety and job satisfaction', *International Journal of Occupational Safety and Ergonomics* 11(3), 291–302. https://doi.org/10.1080/10803548.2005.11076650

Jiménez, F., 2011, 'Introducción: La teoría del crecimiento. Conceptos básicos y breve historia' [Introduction: Growth theory. Basic concepts and brief history], in F. Jiménez (ed.), *Crecimiento económico: enfoques y modelos*, pp. 13–79, Pontificia Universidad Católica del Perú, Lima.

Julca-Vegas, J.A., 2016, '*Crecimiento económico y pobreza en el Perú*un *análisis de datos de panel para el periodo 2004–2013*' [Economic growth and poverty in Peru: A panel data analysis for the period 2004–2013], PhD thesis, Universidad Nacional de Piura, Piura.

Kahraman, E., Akay, O. & Mahmut Kiliç, A., 2019, 'Investigation into the relationship between fatal work accidents, national income, and employment rate in developed and developing countries', *Journal of Occupational Health* 61(3), 213–218. https://doi.org/10.1002/1348-9585.12021

Kim, D.K. & Park, S., 2020, 'Business cycle and occupational accidents in Korea', *Safety and Health at Work* 11(3), 314–321. https://doi.org/10.1016/j.shaw.2020.05.002

Kossoris, M., 1938, 'Industrial injuries and the business cycle', *Monthly Labor Review* 46(3), 579–594.

Lander, F., Nielsen, K.J. & Lauritsen, J., 2016, 'Work injury trends during the last three decades in the construction industry', *Safety Science* 85, 60–66. https://doi.org/10.1016/j.ssci.2015.10.013

Leombruni, R., Razzolini, T. & Serti, F., 2019, 'Macroeconomic conditions at entry and injury risk in the workplace', *Scandinavian Journal of Economics* 121(2), 783–807. https://doi.org/10.1111/sjoe.12285

Lingard, H. & Rowlinson, S., 2005, *Occupational health and safety in construction project management*, 1st edn., Taylor & Francis, New York, NY.

Loayza, N. & Soto, R., 2002, *The sources of economic growth: An overview*, Banco Central de Chile, Santiago.

Loimer, H. & Guamieri, M., 2011, 'Accidents and acts of God: A history of the terms', *American Journal of Public Health* 86(1), 101–107. https://doi.org/10.2105/AJPH.86.1.101

Loomis, D., Schulman, M.D., Bailer, A.J., Stainback, K., Wheeler, M., Richardson, D.B. et al., 2009, 'Political economy of US states and rates of fatal occupational injury', *American Journal of Public Health* 99(8), 1400–1408. https://doi.org/10.2105/AJPH.2007.131409

Łyszczarz, B. & Nojszewska, E., 2017, 'Economic situation and occupational accidents in Poland: 2002–2014 panel data regional study', *International Journal of Occupational Medicine and Environmental Health* 31(2), 151–164. https://doi.org/10.13075/ijomeh.1896.01093

Mankiw, N.G., 2021, *Principles of economics*, 6th edn., Cengage Learning, Connecticut, CN.

McDaid, D. & Suhrcke, M., 2012, 'The contribution of public health interventions: An economic perspective', in J. Figueras & M. McKee (eds.), *Health systems, health, wealth and societal well-being*, p. 125–152. Open University Press, Maidenhead.

Mouza, A.M. & Targoutzidis, A., 2012, 'The impact of the economic cycle on fatal injuries: The case of UK 1971–2007', *Quality and Quantity* 46(6), 1917–1929. https://doi.org/10.1007/s11135-012-9700-9

Ñaupas-Paitán, H., Valdivia-Dueñas, M.R., Palacios-Vilela, J.J. & Romero-Delgado, H.E., 2018, *Metodología de la investigación cuantitativa-cualitativa y redacción de la tesis* [Quantitative-qualitative research methodology and thesis writing], 5th edn., Ediciones de la U, Bogotá.

Nichols, T., Dennis, A. & Guy, W., 1995, 'Size of employment unit and injury rates in British manufacturing: A secondary analysis of WIRS 1990 data', *Industrial Relations Journal* 26(1), 45–56. https://doi.org/10.1111/j.1468-2338.1995.tb00722.x

Nielsen, K.J., Lander, F. & Lauritsen, J.M., 2015, 'The relationship between macroeconomic and industry-specific business cycle indicators and work-related injuries among Danish construction workers', *Occupational and Environmental Medicine* 72(4), 271–276. https://doi.org/10.1136/oemed-2014-102290

Petersen, K., Feldt, R., Mujtaba, S. & Mattsson, M., 2008, 'Systematic mapping studies in software engineering', in G. Visaggio, M.T. Baldassarre, S. Linkman & M. Turner (eds.), *EASE'08: Proceedings of the 12th International Conference on evaluation and assessment in Software Engineering*, BCS Learning & Development Ltd., Swindon, pp. 68–77.

Potter, R., 1997, 'Accidents in the eighteenth century', in R. Cooter & B. Luckin (eds.), *Accidents in history*, pp. 90–106, Clio Medica, Amsterdam.

Revelo-Sánchez, O., Collazos-Ordoñez, C.A. & Jiménez-Toledo, A.J., 2018, 'La Gamificación como estrategia didáctica para la enseñanza/aprendizaje de la programación: Un mapeo sistemático de literatura' [Industrial safety organisation: The costs of industrial accidents], *Lámpsakos* (*revista descontinuada)* 19, 31–46. https://doi.org/10.21501/21454086.2347

Riaño-Casallas, M.I. & Palencia-Sánchez, F., 2016, 'Dimensión económica de la seguridad y la salud en el trabajo: Una revisión de literatura' [The economic dimension of occupational safety and health: A literature review], *Gerencia y Políticas de Salud* 15(30), 24–37. https://doi.org/10.11144/Javeriana.rgyps15-30.dess

Song, L., He, X. & Li, C., 2011, 'Longitudinal relationship between economic development and occupational accidents in China', *Accident Analysis & Prevention* 43(1), 82–86. https://doi.org/10.1016/j.aap.2010.07.014

Sousa, V., Almeida, N.M. & Dias, L.A., 2014, 'Risk-based management of occupational safety and health in the construction industry – Part 1: Background knowledge', *Safety Science* 66, 75–86. https://doi.org/10.1016/j.ssci.2014.02.008

Steele, G.R., 1974, 'Industrial accidents: An economic interpretation', *Applied Economics* 6(2), 143–155. https://doi.org/10.1080/00036847400000004

Swuste, P., Van Gulijk, C., Zwaard, W. & Oostendorp, Y., 2014, 'Occupational safety theories, models and metaphors in the three decades since World War II in the United States, Britain and the Netherlands: A literature review', *Safety Science* 62, 16–27. https://doi.org/10.1016/j.ssci.2013.07.015

Teixidó i Campàs, P., 2009, *La prevención en época de crisis* [Prevention in times of crisis], Barcelona.

Todaro, M.P. & Smith, S.C., 2015, *Economic development*, 12th edn., Pearson, Harlow.

Vieira, R., 2013, 'The epistemology and politics of the accidental: Connecting the accident's intellectual and cultural historiography', *History Compass* 11(3), 227–234. https://doi.org/10.1111/hic3.12035

Wei, J., Lu, L., Zhao, D. & Wang, F., 2016, 'Estimating the influence of the socio-economic inequalities on counties' occupational injuries in central China', *Safety Science* 82, 289–300. https://doi.org/10.1016/j.ssci.2015.09.009