Workers' behavior after safety regulations: Impact evaluation of the Spanish Occupational Safety and Health Act

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ABSTRACT

While the 1995 Occupational Safety and Health Act (OSH) regulation transformed the outlook on workplaces in Spain, characterized by a lack of preventive protection, public statistics have reported an increasing trend in the postregulation workplace accident rates. This study uses microdata from official national statistics to examine the effect of the OSH regulation on the reported accidents while focusing on its severity. Accordingly, we apply a difference-in-difference assessment method where a comparable group is formed by the contemporaneous *in itinere* accidents (commuting), which are legally and statistically considered work-related accidents but not directly impacted by the OSH regulation, with a focus on the workplace environment. The results reveal that the nonfatal accident rate decreased after the implementation of the regulation. However, when we isolate the effect of the regulation on accidents that usually provoke hard-to-diagnose injuries (dislocations, back pain, sprains, and strains), we obtain a significant increase in the accident rate. Moral hazard mixed effects seem to have played a crucial role in these dynamics through overreporting and/or Peltzman effects, often offsetting accident reduction intended by the OSH regulation.

KEYWORDS

OSH, impact evaluation, moral hazard, difference-in-difference.

JEL CLASSIFICATION

K31, I18, D04, H43, J28

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1. Introduction

Occupational health and safety constitutes an essential element of advanced economies because safety policies help stimulate social wealth and, consequently, territorial economic outcomes by promoting the development of safer work environments (Piore and Schrank, 2018).

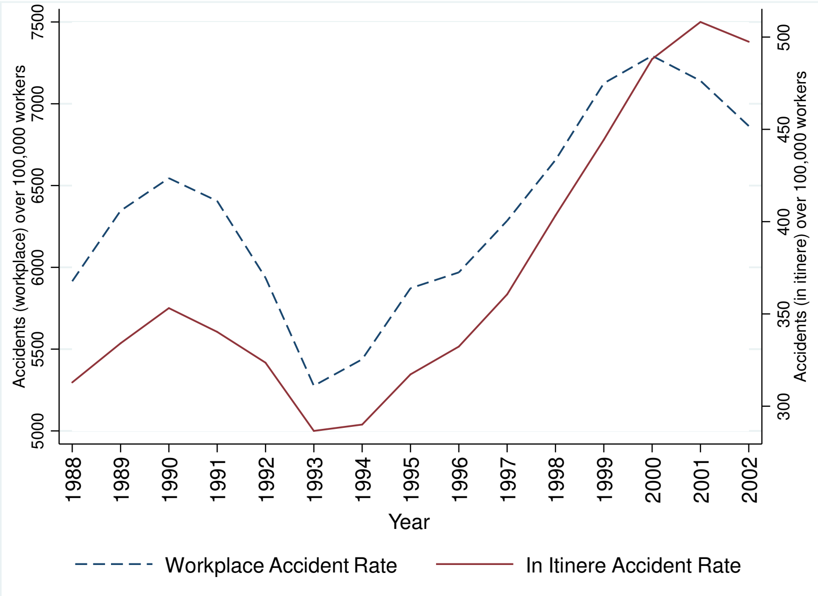
While most developed countries have adopted Occupational Safety and Health Act (OSH) regulations over the past two decades, statistics showed an increase in reported accidents in Spain after the implementation of the 1995 OSH regulation, recording the highest rate for nonfatal accidents across the European Union in 1998 (Dupré, 2001). In fact, accidents at work have persisted as a global concern to date, causing losses of approximately 3.3% of European GDP, as specified by the European Agency for Safety and Health at Work (2017). Similarly, according to the accidents at work statistics published by Eurostat for 2019, there were 3.1 million nonfatal accidents that resulted in at least four calendar days of absence from work and 3,408 fatal accidents in the EU-27, where Spain accounted for higher incidence rates than the European average, especially for nonfatal accidents (ranked third).

Relevant public policy institutions such as OCDE (2020) and the European Union (2016) are promoting *better regulations* that should include ex post impact evaluations to foster competitiveness, employment, sustainable growth, and legal certainty. From a Spanish perspective, inspired by the progress made by other countries, the Royal Decree 1083/2009 stipulated for the first time the need for preceptive ex ante and ex post evaluations of the regulations through "memoranda on the regulatory impact analysis.[1]"

Thus, this paper assesses the effects of the Spanish OSH regulation based on the detailed information contained in the microdata on the cause and consequence of work-related accidents. This study also examines the possible mixed effects related to moral hazard phenomena that may have been diluted in the aggregated public statistics, with the accident rate for both groups being characterized by a decrease in the prelaw period followed by a significant increase in the postlaw period (Figure 1).

[1] The phrase is "memorias de análisis de impacto normativo" in Spanish.

Figure 1. Evolution of the total accident rate



Source: EAT

Accordingly, inspired by the contribution from Ruser (1998) or Martin-Roman and Moral (2017), we used the severity of accidents to identify hard-to-diagnose injuries, which are assumed as more prone to moral hazard and are used as a proxy for minor injuries[2].

Therefore, the empirical specification uses a two-way fixed-effect difference-in-difference quasi-experimental technique, in which the *in itinere* accident rate is determined as a comparable group (counterfactual) for the evaluation, similar to that in Guadalupe (2003).[3] This approach complements the contribution by Arocena et al. (2009), who provided a quasi-experimental framework applied to all accidents reported in Spain, controlling for the unobserved heterogeneity using the same workforce exposed to work-related accident risk as a counterfactual.

The underlying rationale is based on the fact that *in itinere* accidents are considered work-related accidents and receive the same social security protection and statistical treatment (they belong both to EAT[4]) as workplace

[2] We define hard-to-diagnose injuries as those work-related accidents caused by dislocations, back pain, sprains, and strains.

[3] The accident occurred during a one-way journey back and forth between the worker's home and the workplace.

[4] Work-related statistics ("Estadística de accidentes de trabajo," in Spanish).

accidents; however, they were not affected the Spanish OSH regulation. Therefore, we consider that the probability of an *in itinere* accident is mostly independent of the OSH regulation, as they are unaffected by the OSH regulation.

However, this probability will partially depend on the accident susceptibility of the at-risk workforce, which is same for both *in itinere* and workplaces in every period. In turn, both for *in itinere* and workplace accidents, the worker's accident proneness depends on factors such as the reporting propensity, especially in the event of hard-to-diagnose injuries where there is a probability of misreporting. As described previously, these reporting behaviors for only workplace accidents may have been affected by the new OSH regulation, leading to a possible difference in systematic reporting between workplace and *in itinere* accidents after implementing the OSH policy, which could explain the increase in the rate of accidents observed after its implementation.

The study results supported the existence of moral hazard mixed effects depending on the cause and effect of the accident, showing that on the one hand, the OSH regulation significantly reduced the most serious accidents; on the other hand, hard-to-diagnose accidents, which are the most common type of work-related accidents, increased after the implementation of the OSH regulation, partially biasing the meaningfulness of the aggregated statistics.

The latter may have several implications. On the one hand, increase in accident reporting may be a positive consequence of the regulation, preventing workers from working while being injured, as may have happened in the past, improving the welfare of Spanish workers. On the other hand, the regulation may have encouraged labor absenteeism, especially among those workers whose propensity was curbed by the lack of a protection scheme. This may have involved enormous costs in terms of public funds.

These results, which are especially meaningful considering that the OSH regulation was implemented during a procyclical period generally regarded in the literature with a general increase in accident rates, contribute to better and more technical designs of future OSH policies, particularly for in-depth monitoring of some types of accidents that could have adverse effects on the public social security system.

This study is organized as follows. In section 2, the conceptual background summarizes the state of the art, the key features of the Spanish OSH regulation, and the principles of better regulation. In section 3, we describe the identification strategy. Section 4 deals with the empirical strategy setting and the econometric specification, while section 5 shows the result of the estimations. Finally, section 6 concludes with a summary of the results and its policy implications.

2. Conceptual background

2.1. State of the art: factors conditioning the accident rate

Safety at the workplace has traditionally attracted much interest as it requires an efficient institutional framework formed by regulation, institutions, and public officials to optimize the effort and resources deployed by firms and employers for preventing accidents. In this respect, Gyekye and Salimen (2006) highlighted that the probability of work-related accidents depends mainly on the workers' internal characteristics (i.e., aversion to risk or proneness to report an accident) and the working environment's external factors, such as OSH regulation or the economic cycle.

Due to externalities and informational problems such as moral hazards and adverse selection, economic actors are unable to ensure a proper investment in prevention from the market (Viscusi et al., 2018). Therefore, to oblige employers to ensure an acceptable level of security at workplaces, public administrations intervene in the market through OSH policies, mainly in the form of OSH regulations. This was the case in Spain, where the earlier 1971 OSH regulation consisted of a set of quick-fix mechanisms after an accident, rather than focusing on preventing recurring accident, as the 1995 OSH regulation eventually implemented.

While some studies have identified the positive effects of adopting OSH regulations (Wilson et al, 2007; Andersen et al; 2018), other studies (Bartel and Thomas, 1985; Viscusi, 1986) and the workplace statistics have reported an increase in the reported accident incidence rates, as was the case in Spain for certain types of accidents.

In fact, the insurance provided by OSH regulation can influence workers' behavior with respect to observed injury and claim incidence, length of absence, and cost (Ruser and Butler, 2009) through two types of moral hazard (Butler and Worral, 1991). First, "risk-bearing" moral hazard, traditionally known as the Peltzman effect, in which higher benefits related to OSH policies induce workers to take more ex ante risk as risk is perceived to be lower (Peltzman,1975). Second, "claims reporting" moral hazard, in which increased benefits enabled by OSH policies have no effect on the actual injuries (the risk being the same) but more claims are filed (overreporting).

Overall, implementing an OSH regulation may result in mixed effects. On the one hand, accidents reported may increase because of moral hazard (risk-bearing and claims reporting), on the other hand, accidents may decrease as intended by the provision of the OSH regulation adopted (we define this effect as "risk-reducing regulation effect").

The outcome will depend on factors such as enforcement of the regulation (Scholz and Gray, 1990 or Bradbury,2006) or severity of the injury. In fact, minor injuries are empirically associated with an increase in reported accidents that may offset the risk-reducing regulation effect (Ruser and Butler, 2009; Butler and Worrall, 1991).

Researchers have also focused on the direct relationship between the economic cycle and work accident rate as another external relevant factor attention (e.g., Lanoie, 1992; Davies et al.; 2009; Svensson, 2010; Asfaw et al. 2011; Boone et al., 2011; Song et al., 2011; Lafuente et al 2020 or Lafuente et al., 2021). According to two traditional theories, the basic idea is that the economic cycle affects the production factors, and this may influence work-related accidents.

First, the intensification theory proposed by Kossoris (1938) focuses on the necessary increase in the offer of goods and services to meet the increasing demand during a period of economic growth. In this case, if there is no improvement in the state of technology, the new equilibrium will require more workers and/or extra work hours. In this regard, as highlighted by Nichols (1989), during economic growth, the economic agents take long to hire more workers, thus overloading the existing workers. Finally, the translation of the bigger and/or more intensive workforce into a higher accident rate can occur through two mechanisms. First, an increase in the workload may make a worker more prone to work-related accidents, especially new or inexperienced workers. Second, some researchers (Gerdtham and Ruhm, 2006; Davies et al., 2009) have identified a notification effect from the overreporting of minor accidents as workers find that the cost finding a job, in the case of dismissal, is relatively lower when the economy is growing (e.g., Boone and van Ours, 2006; Boone et al., 2011; Li et al., 2011; Fernández-Muñíz et al., 2018).

Second, the vulnerability approach developed by Nichols (1989), based on behavioral economics and labor-market argument studies, such as those by Wright and Lund (1998) or Fernandez-Muñiz et al. (2018), link the higher entry of new workers during growth periods with an increase in the proportion of inexperienced newcomers, which tends to increase the rate of minor accidents.

Concerning periods of economic crisis, Bonne and Van Ours (2006) highlighted that the positive correlation between the economic cycle and the accident rate is due to the lower incentives of workers for reporting minor accidents as they fear to be fired. Similarly, as De la Fuente et al. (2014) proposed, while it could be argued that firms may opt to reduce their workforce during a crisis, the reduction may mainly impact inexperienced workers (as, at least in Europe, dismissal costs of less experienced workers are much lesser than those of experienced workers) as they may have a higher propensity to experience work-related accidents.

Finally, studies such as Terres et al. (2004) developed a framework for Spain where both traditional approaches are combined to affirm that recessions reduce the accident rate because of the simultaneous impacts of intensification and vulnerability.

2.2 Summary of the OSH regulation in Spain

The origin of the current OSH regulation is explained by the OSH Framework Directive (Directive 89/391/EEC), which sets general principles to improve health and safety at the workplace, complemented by other evolving directives that define minimum safety standards and enforcement mechanisms, inspired by similar mechanisms in countries such as Australia, the United States, and Canada[5].

This study assess the transposition of these principles into Spanish legislation conducted by the regulation, the Occupational Risk Prevention in December 1995 (Ley 31/1995 de Prevención de Riesgos Laborales), and other subsequent royal decrees enacted in 1996.

[5] For a summary, see Arocena and Nuñez (2009) p.161.

As highlighted by Sesé et al. (2002), this new legal framework proposes a proactive approach, establishing a culture of prevention by promoting safety and health education at all levels.

Accordingly, the core of the regulation is the involvement of managers in the planning of preventive actions, assessment of the workplace-related risks, including periodical updates, and the arrangement of a coherent and comprehensive set of corrective measures for every kind of risks and an assessment of these measures.

Essentially, the principles (article 15) of this preventive framework are as follows: (a) avoid risks; (b) evaluate the risks that cannot be avoided; (c) fight the risks at their origin; (d) adapt the work to the person; (e) consider the evolution of techniques; (f) replace dangerous conditions by alternatives that involve little or no danger; (g) plan prevention by seeking a coherent framework that integrates the technique, conditions and organization of work, social relations, and the influence of environmental factors at work; (h) implement the measures that place group protection before the individual; and (i) give safety instructions to the workers.

Concerning the reporting system, whose main features are homogeneous for 1988–2002, it is important to highlight that an accident must be reported by the employer to the Social Security. *In itinere* accidents by any mean happening during working hours are also included as a work-related accident, together with accidents at the workplace accidents. Also, work-related accidents without sick leave granted and those where the worker had an accident but is able to come back to work on the same day are included. Regarding fatal accidents, which are not targeted in this paper as they are obviously exempt from behavioral considerations, only accidents causing immediate deaths are considered as fatal accidents, which may introduce bias in the fatal accident rate reported in the statistics. The EAT statistics include the data on these accidents, whose methodology remained constant over the period analyzed.

Regarding compensation in the event of a work-related accident, generally, the insurance system covers employed workers and agriculture and fishing self-employers. Premiums, as Terres et al. (2004) claimed, are paid by employers according to a fee schedule in force from 1979 arranged by jobs with 126 epigraphs (and five additional epigraphs with types of surcharges).

2.3. Better regulation

Since the early 2000s, where the emphasis was focused on deregulation, national public administrations such as the United Kingdom, Germany, the Netherlands, and Denmark reoriented the design of regulations that should be better prepared to improve national economies and their ability to adapt to change, avoiding unnecessary costs and administrative burdens. These concerns were part of the European debates, while national administrations advanced through the implementation of tools and principles currently part of the legal system of many countries[6] and broadly known as better regulation principles[7].

Later, in 2015, the European Commission published a "better regulation package," in which new proposals and toolkits attempted to improve the quality of economic regulation. This initiative was officially implemented when the three main European Union institutions (European Parliament, the Council of the European Union, and the European Commission) signed a binding interinstitutional agreement on better-law making in 2016, "*recognizing their joint responsibility in delivering high-quality Union legislation and in ensuring that such legislation focuses on areas where it has the greatest added value for European citizens (….) to strengthening the competitiveness and sustainability of the Union economy."*

This agreement adopted most of the better regulation principles and emphasized the importance of the ex post evaluation of the existing legislation based on *"efficiency, effectiveness, relevance, coherence, and value added, should provide the basis for impact assessments of options for further action."*

In Spain, after receiving recommendations from the OCED in 2012 and 2014 to include an evaluation of the regulatory activity, the Royal Decree on Memorandum on the Regulatory Impact Analysis (Memoria del Análisis de Impacto Normativo) updated the existing normative in 2017 and specified the obligation for an ex post assessment of the supposed results by regulations.

Despite all initiatives and efforts by the administration, the OECD identified in its Regulatory Policy Outlook in 2021 that one of the critical gaps

[6] Art 129 Ley 30/2015.

[7] Also known as a smart regulation of efficient regulation. While there may be minimal variation across countries, the most common better regulation principled had its origin in the 1998 Better Regulation Task Force of the UK and include Necessity, Proportionately, Effectiveness, Accountability, Consistency, and Transparency.

of the regulatory policies and its implementation across OECD members stems *from the very limited focus on ex post evaluation of laws and regulation partly due to the limited amount of resources and investments. Many regulations often remain on the statute books without ever being evaluated whether they are fit-for-purpose and achieve the goals for which they were adopted. While the ex ante assessment of newly developed regulations is becoming more common, it is much rarer that governments systematically review regulations after a certain period of time, besides ad hoc reviews mostly focusing on administrative/regulatory burden reduction.*

Thus, this study contributes to the development of a necessary culture of evaluating the policies and regulations implemented by the public administration.

3. Identification strategy

3.1.Moral hazards in insurance markets

As highlighted by Ruser and Butler (2009), workers' compensation insurance (including sickness and income benefits) and tort law provide strong incentives that influence workers' behavior and firms with respect to the observed injury and claim incidence, duration of absence, and costs. From a Spanish perspective, Martin-Roman and Moral (2016, 2017) observed behavioral effects concerning claim incidence and found evidence regarding the duration of moral hazard in Spain.

Specifically, from an employee perspective, as highlighted by Poliakas and Theodossiou (2013), safety precautions, filing claims, and the duration of leaves after an accident may all be influenced by the anticipation of ex post compensation (moral hazard).

This moral hazard, within the framework proposed by Butler and Worral (1991), can be of two types: "risk-bearing" moral hazard in which higher benefits related to OSH policies induce workers to take more ex ante risks and "claims reporting" moral hazard where the higher benefits enabled by OSH policies have no effect on the actual injuries (the risk is the same) but more claims are filed.

Therefore, any intended positive impact related to the higher safety improvements (fewer reported accidents) might be mitigated (even offset) by a reduction in employees' vigilance and the subsequence increase in the frequency of claims, including possible fraudulent claims. Thus, this study determines which of these effects prevailed after implementing the Spanish OSH regulations, which came into force between December 1995 and late 1996.

3.2. Choice of *in itinere* accidents as counterfactual

Similar to Guadalupe (2003), this study relies on the *in itinere* accident rate (commuting accidents) as a comparison group for the evaluation.

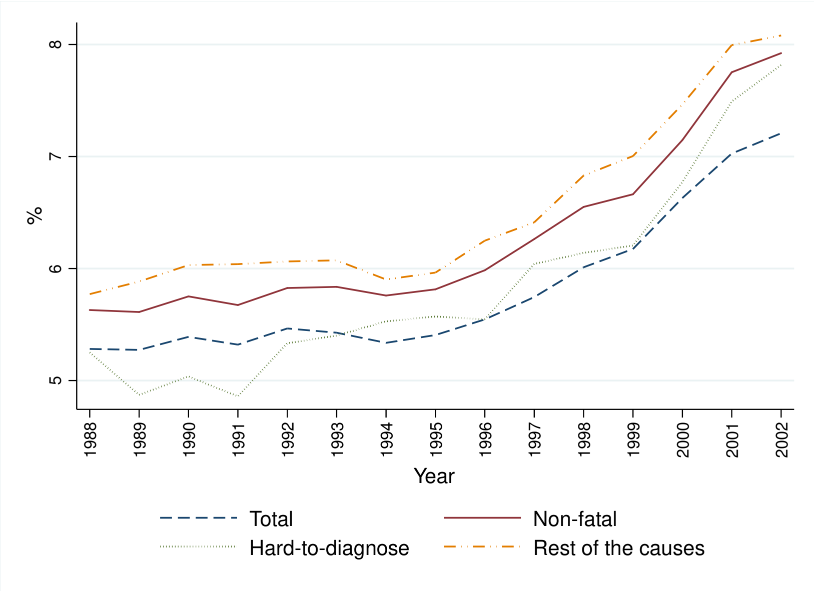
In itinere statistics are theoretically suitable for comparison because both statistics (accidents at workplace and *in itinere*) refer to the same workforce over time. In other words, every worker in a specific year is susceptible to suffering an *in itinere* accident or a workplace accident, and this accident will be captured in the EAT data as both accidents are considered work-related and thus receive the same insurance protection.

However, a key aspect of the analysis is that *in itinere* accidents rate is not expected to be directly affected (exogeneity condition) by the Spanish OSH regulation, which focuses only on the workplace environment. Therefore, we believe that the probability for an individual of having an accident *in itinere* is independent of the OSH regulation as they are unaffected by the OSH regulation. Instead, this probability depends on the workers susceptibility to accidents, considered identical for both *in itinere* and at the workplace and depending, on factors such as the reporting propensity, specifically in the event of hard-to-diagnose injuries where misreporting is more likely.

As described earlier, these reporting behaviors, which apply exclusively to workplace accidents, may have been affected by the new OSH regulation, creating a difference in systematic reporting between workplace and *in itinere* accidents after the implementation of the OSH policy, which may partially explain the increase in the accident incidence observed after implementing the OSH regulation.

In this respect, Figure 2 offers a proxy for validating the identification strategy, as proposed by Guadalupe (2003). If our counterfactual (*in itinere* accidents) captures the differential change in the moral hazard proneness between the groups, the *in itinere*/workplace accident (nonfatal) ratio should be stable over time if the OSH regulation had no effect. As illustrated in Figure 2, the proportion of *in itinere* accidents over total workplace accidents increased after implementing the OSH, which already introduce the possible existence of differentiated behaviors across both groups. This trend remains similar if we focus only on nonfatal accidents, regardless of the cause of the accident.

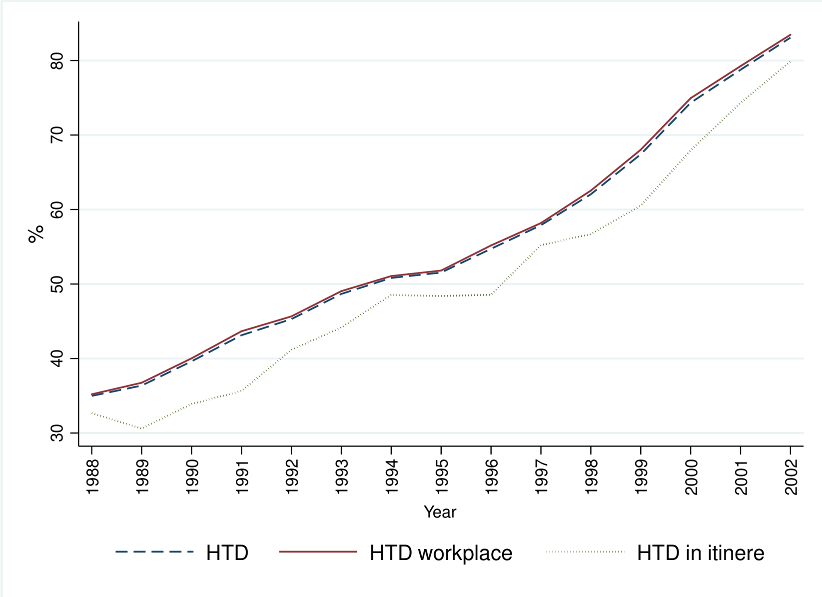
Figure 2. Ratio *in itinere*/workplace



Source: EAT

Similarly, regarding the evolution of hard-to-diagnose ("HTD") injuries over the period analyzed, Figure 3 shows an increase in the proportion of hard-to-diagnose injuries over the rest of nonfatal accidents, with similar trends for both workplace and *in itinere* accidents. In this respect, authors such as Robson et al. (2001) highlighted that "*A good indicator of the underreporting effect is the quotient between minor and major accidents. Minor injuries are more likely to be filtered than major injuries. If the quotient remains constant, it is an indicator of the stability of any bias by underreporting (or absence of underreporting).*" As displayed in Figure 3, the increasing trend accelerated after the implementation of the OSH regulation, which could indicate a proxy for the presence of moral hazard behaviors.

Figure 3. The evolution of the ratio between hard-to-diagnose accidents and the rest of the accidents



Source: EAT

3.3. Determinants of the injury probability

Against this background, the identification strategy can be algebraically expressed as follows:

Considering that events P (the real probability of having a work-related accident) and Q (the probability of reporting an accident that has occurred) are independent events, S (the probability of the existence of a reported accident in the EAT by an individual) can be summarized under the setting described in equation 1:

$$S(R) = P(R) \times Q(R) \qquad (1)$$

Concerning the effect of the introduction of the OSH regulation at the aggregated level, based on the incidence rates constructed through the aggregation of individual anonymized data, we find the two following mixed effects:

- One, the variation in the probability of suffering a work-related accident at the workplace after the regulation (other things being equal) is ambiguous (equation 2).

$$\frac{\partial P(R)}{\partial R} \lesseqgtr 0 \qquad (2)$$

Considering that *in itinere* accidents remained unaffected, depending on the prevalence of one of the aforementioned effects, the number of accidents may increase if risk-bearing moral hazard prevails (equation 2.1.), decrease in the event of the prevalence of the intended risk reduction effect (equation 2.3.), or stay constant if the magnitude of both effects is equal (equation 2.2.). Algebraically, this can be modeled by the following equations:

$$\frac{\partial P(R)}{\partial R} \begin{cases} > 0 \; if \; moral \; hazard \; related \; effect \; prevails & (2.1) \\ = 0 \; if \; both \; effects \; offset \; each \; other & (2.2) \\ < 0 \; if \; intended \; risk \; reduction \; effect \; prevails & (2.3) \end{cases}$$

- Two, concerning the variation in the probability of reporting an accident (other things being equal) both at the workplace and *in itinere*, there is no apparent logical reason for reduction after implementation of the regulation (equation 3). Instead, the most common consequence will be an increase in the reporting as workers will feel more protected against being fired by the OSH regulation, which can be expressed in formal terms as follows:

$$\frac{\partial Q(R)}{\partial R} \geq 0 \qquad (3)$$

This increase in the reported accidents can be interpreted positively (workers reporting accidents that could not be reported before the OSH regulation as they feared negative consequences) or fraudulently (workers exaggerate or invent minor accidents, with the OSH regulation being a facilitating factor). Thus, factors such as the severity of the accident play a crucial role in this case.

Overall, the marginal effect of the adoption of the OSH regulation on the reported accidents is framed as follows:

$$\frac{\partial S(R)}{\partial R} = \underbrace{\frac{\partial P(R)}{\partial R} \times Q(R)}_{\lesseqgtr 0} + \underbrace{\frac{\partial Q(R)}{\partial R} \times P(R)}_{>0} \lesseqgtr 0 \qquad (4)$$

In conclusion, as described in equation 4 and detailed in the following sections of this study, the adoption of an OSH regulation may have entailed an increase in the reported accidents if moral hazard (risk-bearing and/or claim reporting) effects offset the intended risk reduction effect. In contrast, the OSH regulation may also have decreased the reported accidents if the risk reduction effect prevailed. Finally, it could be possible that both effects balanced each other perfectly, causing no variation in the reported accidents.

4. Empirical setting

4.1.Data: Sources and aggregation

In Spain, an employer is legally obliged to insure all workers by choosing between the public national security system or a private insurance company, with a proportionally determined premium based on the wage.

In the event of a labor accident, workplace or *in itinere*, there is an obligation to report the accident and inform the insurance company and the Spanish Ministry of Labor, which publishes annual aggregated statistics at the province level (NUTS-3 level)[8] in the EAT, one of the sources used for this analysis.

However, this source does not contain any disaggregated information on other features related to accidents at work, such as the cause, consequence, duration, or place, which would hinder conclusion on moral hazard behaviors. Therefore, we sought microdata from the Spanish Labor Ministry, whose information on mainly cause and consequence has been used to define the hard-to-diagnose minor injuries used as a moral hazard proxy herein.

Concerning the temporal dimension, it covers 15 complete years from 1988 (first year available) and 2002. This analysis has not been extended from 2002 as the data collection methodology of the EAT partially changed in 2003, which would have biased the results.

[8] NUTS stands for the Nomenclature of Territorial Units for Statistics and is the official statistical territorial classification in the European Union. This classification has three levels, level number 3 being the more disaggregated and corresponding to provinces (“Provincias”) in Spain.

The annual aggregation at the province level of every accident reported in the EAT (more than 11 million between 1988 and 2002) comprises the dataset used in this study. As data for every province is available for each year for both the treated (accidents at workplace) and the counterfactual (*in itinere* accidents), we have a balanced repeated cross-sectional data with 1,500 observations for each group because of the length of the panel (15 years) multiplied by the number of provinces (50).

All variables used in this study are used in terms of the accident incidence rate every 100,000 workers, where the microdata have been aggregated according to the following formula:

$$Accident\ rate_{p,y} = \frac{number\ of\ accidents_{p,y}}{\left(\frac{number\ of\ workers_{p,y}}{100{,}000}\right)} \quad (5)$$

Here, p refers to the province and y indicates the year in which the accident occurred.

The total number of workers (NoW) refers to the workforce subject to risk that belongs to the EAT, whose number is inferred from the aggregated index published in the EAT as indicated in equation 6, complemented by the numbers of accidents from the microdata:

$$NoW_{p,y} = \frac{NoW\ from\ microdata_{\ p,y}}{Accident\ rate_{p,y}} \times\ 100{,}000 \quad (6)$$

4.2. Econometric specification

To analyze the effect of the OSH regulation, we used a two-way fixed effects (time and province) difference-in-difference strategy, where the treated group is the workplace accident rate (directly impacted by the regulation) and the control group is the *in itinere* accident rate (unimpacted by the regulation).

To address the possible bias related to heteroscedasticity and autocorrelation, we use clustered (province) robust standard errors, as suggested by literature (White, 1984; Arellano, 1987; Bertrand et al. (2002, 2004). We also account for the specific influence of time and province by the inclusion time (year) and province-related fixed effects (Pischke, 2005; Wing et al. 2018). Moreover, as there is an intrinsically large difference in scale (among other reasons, because the number of hours at risk at workplace is bigger than *in itinere*) between *in itinere* and workplace accidents rate and to be able to extract comparable and easily interpreted results, we use the natural logarithm of the accident rate, which also helps to infer incremental changes from the results.

The specification is modeled as follows:

$$\log Accident\ Rate_{it} = \alpha + \eta D_{it} + P_i + Y_t + E_{it} \qquad (7)$$

The dependent variable is indexed[9] and represents the average accident rate of all Spanish provinces for each year between 1988 and 2002.

Here, α is the constant term or intercept and D is the parameter of interest formed by the interaction term between a dummy variable *"post"* (that takes value equal to one (zero) if the accident occurred after (before) the intervention reference period) and the dummy *"treated"* (value is equal to one (zero) if the accident occurred at the workplace (*in itinere*)), indicating the possible differential impact of the regulation on the accident rate between the workplace and *in itinere.*

Unlike the canonical difference-in-difference specification without fixed effects, both dummy variables, *"post"* and *"treated,"* should be omitted in equation (7) as they are perfectly collinear to the included fixed effects.

Concerning the intervention reference period, it is supposed to have started in 1997 as in Arocena and Nuñez (2009), considering that the law started to have an effect only once the developing regulations entered into force (end 1996).

Furthermore, *P* and *Y* are province-type-of-accident and year-fixed effects, whereas *E* refers to clustered (province) robust standard error. Finally, the subindex *i* indicates the kind of accident (total accidents or nonfatal accidents) and the subindex *t* refers to the year the accident happened.

We apply equation (7) to estimate the impact of the regulation on the total accident rate **(Block A)** and the nonfatal accident rate **(Block B)**, using the following same five specifications.

[9] The index of accidents is calculated as the number of accidents over 100,000 workers.

The first specification focuses on the aggregated microdata, which is referred to as *all causes (1) in* the results section.

To extract some input from differentiated impacts related to the possible existence of moral hazard behavior, we propose two groups of alternative specifications:

- The first group of alternative specifications, identified as *Cause more prone to moral hazard*, addresses the possible existence of moral hazard behaviors through the impact of the regulation on accidents caused by overexertion, referred to number (2) in the results section.

  In this respect, overexertion constitutes the most frequent cause of overall work-related accidents (23% of the total of nonfatal) and the most prone to moral hazard behaviors as 75% of accidents caused by overexertion resulted in hard-to-diagnose injuries. A description of the most frequent accidents based on the cause of the accident is provided in the annex [10].

- The second group of alternative specifications, identified as *causes less prone to moral hazard*, focuses on accidents caused by falls at different levels (30% provoked hard-to-diagnose injuries) and hits by mobile objects (20% provoked hard-to-diagnose). They are referred in the results sections as specifications (3) and (4), respectively.

4.2.1. Validation of the empirical strategy

The difference-in-difference approach relies on the assumption that the relevant unmeasured variables are either group-invariant attributes or time-varying factors that are group invariant. Together, these restrictions imply that the time series of outcomes in each group should differ by a fixed amount in each period and should exhibit a common set of period-specific changes. This is broadly known as the common/parallel trend assumption, which assumes that in the absence of treatment, the average outcome for the treated and control group would have evolved in parallel.

[10] Tables A.3., A.4., and A.5.

Under the common trend assumption, the coefficient *"treated"* captures the time-invariant difference in outcomes between the groups. Implicitly, the group coefficient captures the combined unmeasured covariates that differ systematically between the groups and that do not change over the course of the study period.

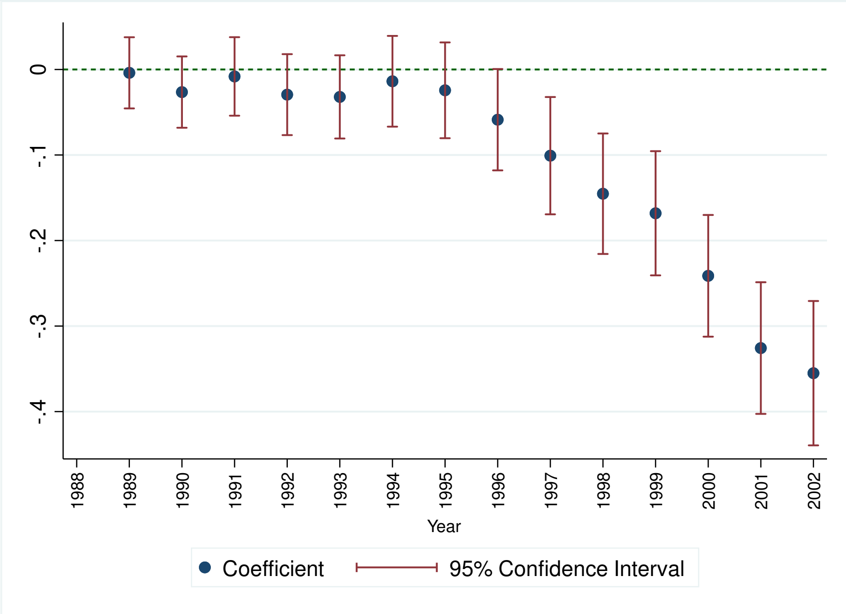
Similarly, the coefficient on "post" captures the combined effects of any unmeasured covariates that change between the periods but affect the outcomes similarly in both groups.

To approximate the existence of parallel trends, researchers should carefully consider the conceptual reasons for which the common trends assumption might be valid in some settings and not in others. It may be helpful to interpret the common trends assumption as a byproduct of a set of underlying variables that differ across provinces and change over time.

In our case, where the at-risk workforce is identical for both groups over time, it is illogical to consider any factor that may affect the accident rate differently across time and across groups, regardless of whether the factors are time-invariant group attributes or group-invariant time-varying factors.

In addition to the theoretical reasoning, it is convenient to empirically test the possible existence of the parallel trend condition. Besides the classical graphical approach shown in Figure 1, which seem to exhibit parallel trends between both groups for the nonfatal accident rate (99% of the total accidents), we create an event study including the leads and lag methodology as used by Abrams (2012); Pischke (2005) or Autor (2003) to test whether there are statistically significant differences between the group (treated and counterfactual) characteristics over the years before the intervention. In practice, we regress the aggregate accident rate on the full factorial of the year-fixed effect with the treated dummy. The results in Figure 4 show that it is not possible to reject the hypothesis (at 5%) and that there were parallel trends over the years before the intervention, validating the empirical strategy for all specifications used.

Figure 4. Evolution of the effect of the OSH regulation on the overall accident rate over the period analyzed



Source: Own elaboration

Note: 1988 set as a reference period

Finally, the second key assumption, strict exogeneity, requires that the OSH regulation is not predicted by prior accident rates, conditional on province and time-fixed effects (Wing et al. 2018; Wooldridge, 2007). This assumption has also been tested using leads and lags for every specification, confirming the absence of significant coefficients before the intervention, reinforcing the validation of the model.

5. Results and discussion

The results of Table 1 show that, unlike the trend displayed in Figure 1, the total accident rate (Block A) and nonfatal accident rate (Block B) have generally (specification 1) experienced a similar significant overall decrease of approximately 18 p.p. after the OSH regulation[11], implying that the new preventive approach of the OSH regulation was generally effective in its assumed goal of improving safety in the workplace.

[11] The results in Table 1 are expressed in the logarithmic points. In the text, to ease the interpretation, the results are transformed into percentage points (p.p.) using the formula $\%\Delta y = \exp(\Delta\beta) - 1$.

This result, consistent with the evidence of the impact of legislative stock in Spanish accidents conducted by Terres Ercilla et al. (2004), is especially meaningful if we consider the economic growth period after the OSH regulation in Spain, with increasing GDP and decreasing unemployment, usually associated with an increase in accidents (Gerdtham and Ruhm, 2002; Neumayer, 2002; Tapia Granados, 2002; and Terres Ercilla ,2004) either as a result of an intensification of the general workload (Kossoris, 1938) or related to the higher proportion of vulnerable workers (Nichols,1989).

However, the insurance provided by OSH regulation can influence the workers' behavior with respect to the observed injury and claim incidence, duration of absence, and cost (Ruser and Butler, 2009) through two types of moral hazard (Butler and Worral, 1991). First, "risk-bearing" moral hazard, in which higher benefits related to OSH policies provoke workers to take more ex ante risk as risk is perceived to be lower, which is traditionally known as the Peltzman effect (Peltzman,1975). Second, "claims reporting" moral hazard, in which the higher benefits enabled by OSH policies have no effect on the actual injuries (the risk is the same) but more claims are filed (overreporting).

Therefore, we have identified interesting twofold effects that remain robust for both blocks, depending on the moral hazard proneness of the cause of the accident.

On the one hand, we have detected nearly 33 p.p.–35 p.p. increase in the accident rate of those accidents classified as more prone to moral hazard issues (specification 2), which implies the prevalence of one of the moral hazard behaviors (risk-bearing and claims reporting) over the risk reduction intended effect.

Indeed, the increase in the accident rate may be due to the combination of the OSH to a lower perception of risk (Peltzman effect) and the possible overreporting of accidents, which may in turn be related to prior underreporting due to factors such as ignorance, lack of trade union representation, workers' sense of guilt or their fear of losing their job, injure their career, or being considered as prone to risk (Boone and Van Ours, 2002; Terres Ercilla, 2004). In fact, Terres Ercilla (2004) already detected underreporting before the OSH regulation in the answers to the interviews conducted by experts and professionals from Spanish administrations and other stakeholders.

On the other hand, the results identify a decrease in the accident rate of less prone moral hazard causes (specifications 3 and 4) that ranges from 23 p.p.

to 25 p.p. , implying that, in the absence of moral hazard, the measures included in the OSH regulation may have better achieved its assumed preventive goals.

These results confirm the mixed effects of the OSH regulations, which could generally reduce the aggregate accident rate and the most severe accidents while increasing the hard-to-diagnose accidents[12]. As discussed, factors such as risk perception or overreporting seem to have played a key role in these coefficients.

Indeed, the lower reduction in the aggregate accident rate (1), around 18 p.p., compared with the causes less prone to moral hazard (3 and 4), from 23 p.p. to 25 p.p., seems logical as the aggregated accident rate contains every cause, including causes related to hard-to-diagnose injuries, which biased downward the positive impact (reduction) of the regulation.

Overall, the OSH regulation achieved its assumed preventive goal as the accident rate, including fatal accidents, decreased once the regulation was implemented[13]. However, this study has been able to disentangle differentiated results, revealing the possible cumulative existence of moral hazard behaviors and other drawbacks arising from the OSH regulation, increasing the accident rate for certain types of accidents. As discussed in the conclusions, the previous underreporting state, lower risk perception, and tighter control of these accidents are likely behind these results, leaving room for improvement for future policies.

[12] A graphical approach of these mixed results is provided for illustration purposes in table A.6. of the Annex.

[13] Table A.7. of the Annex shows the impact of the OSH regulation on fatal accidents, which has been omitted from the body of the paper as logically being excluded from moral hazard considerations. The results show a significant decrease in the accident rate, confirming the intended reduction by the OSH regulation.

Table 1. Results of the impact of the OSH on the accident rate

Dep. Variable = log of the accident rate over 100,000 workers	Block A-Total accident rate				Block B-Nonfatal accident rate			
	All causes (1)	More prone to Moral Hazard	Causes less prone to Moral Hazard		All causes (1)	More prone to Moral Hazard	Causes less prone to Moral Hazard	
		Overexertion (2)	Falls at different levels (3)	Hits by mobile objects (4)		Overexertion (2)	Falls at different levels (3)	Hits by mobile objects (4)
Constant	7.148*** [0.012]	4.380*** [0.043]	2.754*** [0.043]	3.838*** [0.037]	7.330*** [0.013]	4.376*** [0.043]	2.745*** [0.041]	3.831*** [0.037]
D	**-0.201*** [0.023]**	**0.301*** [0.063]**	**-0.264*** [0.051]**	**-0.274*** [0.056]**	**-0.191*** [0.030]**	**0.290*** [0.064]**	**-0.265*** [0.052]**	**-0.292*** [0.054]**
Nº observations	1500	1471	1402	1479	1500	1471	1398	1478
R2_adjusted	0.696	0.369	0.146	0.145	0.816	0.367	0.144	0.150
Note. Standard deviations in square brackets.						legend: * p < .05; ** p < .01; *** p < .001		

Source: EAT

6. Conclusions and policy implications

This study has analyzed the impact of the Spanish OSH 1995, whose main objective was to increase safety at workplaces. Unlike the aggregated statistics publicly available, where an increasing trend of the accident rate it is observed in the period after the regulation, the analysis based on microdata has revealed a general decrease in the accident rate, including complex effects depending on the cause and severity of the injuries caused by the accidents.

Specifically, the results have shown that Spanish OSH regulation was able to reduce the most severe accidents, the main source of deaths, and serious injuries. This may be associated with a higher effort by the economic agents and administration in structural issues from sectors more intensive in terms of physical effort or the use of potentially dangerous machinery, such as construction or industry. In this regard, it results potentially less complexed for the prevention actors to target dangerous and predictable work-related actions (e.g., using a proper helmet in a quarry) compared to random events that might take place (e.g., slips or strains). Finally, the workers' risk awareness tends to be lower with regard to hard-to-diagnose accidents, which also may partially explain the differential impact of the OSH regulation.

Besides, the results have confirmed the existence of moral hazard behaviors related to the implementation of the OSH regulation. As described in this study, together with the possible overconfidence that result in workers being less aware of certain risks, workers also have a degree of discretion to report some accidents, especially minor accidents (hard-to-diagnose) that depend on several factors, such as a more protective regulatory scheme, whose implications can be shaped into two main perspectives.

First, this increase may be a positive consequence of the regulation, preventing workers from working while being injured, as may have been the case before the regulation, where there was apparent underreporting. Accordingly, Davies et al. (2009) found that more bargaining power favored by new regulations is related to higher rates of minor injuries. Consequently, the OSH regulation would have increased the welfare of Spanish workers.

Second, the regulation may have encouraged labor absenteeism, especially in those workers whose propensity to absenteeism was contained by the lack of a protection scheme. This may have led to enormous costs in terms of public funds, productivity, and various public resources (health, education, etc.).

Overall, this study has contributed to a necessary culture of evaluation of OSH public policies and regulations, which is usually avoided by policymakers and academia (Viscusi, 2006), and set a starting point for further quasi-experimental evaluations in Spanish regulations. In fact, in a context where compensation costs are increasing, public administrations should seek explanatory factors behind the regulations, understand accidents claims, monitor moral hazard behaviors, and estimate its impact (Butler and Worrall, 2009) on the society. Indeed, while the number of accidents resulting in severe injuries and deaths seems to have decreased, there is significant room for improvement in the case of minor injuries, which, as the most common cause of accidents, should not be neglected in cumulative relevance in terms of monetary cost and productivity.

As Sesé et al. (2002) highlighted, Spanish prevention should be based on safety explanatory models that offer the opportunity to obtain a good diagnosis of the state of health and safety and of the workplace. In this respect, it is important that the administration adopts a more technical and in-depth analytical to avoid biased interpretations than can be drawn from the published aggregated statistics, which may partially undermine the legitimacy of the public policies implemented.

Finally, as highlighted by Lafuente et al. (2020), perhaps it is time to redesign incentives for employers to increase safety at the workplace through incentive mechanisms such as lower insurance premiums or tax deductions for firms that comply with the OSH standards and have excellent records over time.

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ANNEX.

Table A.1. complements the information displayed in Figure 1, providing statistics depending on the place of the accident. We can observe that there are no notable differences in the composition of both groups. Moreover, as expressed by the ratios of the bottom-half of Table A.1., there are no substantial differences across groups.

Table A.1. Summary of the main statistics depending on the place

Variable	Accidents at workplace (750 observations)				Accidents at workplace (750 observations)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Total accident rate	5986.913	1432.399	2730.927	10399.540	382.484	160.361	100.127	913.900
Fatal accident rate	8.800	4.877	0	31.264	4.731	2.580	0	20.158
Nonfatal Accident Rate	6324.741	1487.688	2988.990	10754.830	368.405	156.030	94.858	908.488
Hard-to-diagnose nonfatal accident rate	2122.128	744.662	571.190	4817.132	129.008	79.403	12.593	528.097
Rest of nonfatal accidents rate	3856.197	930.939	1866.192	7463.208	248.900	97.848	73.778	591.271
Fatal accidents/total accidents	0.002	0.001	0	0.008	0.014	0.011	0	0.088
Nonfatal accidents/total accidents	0.998	0.001	0.992	1.000	0.986	0.011	0.912	1.000
Hard-to-diagnose of nonfatal accidents/nonfatal accidents	0.350	0.069	0.189	0.542	0.325	0.094	0.091	0.657
Rest of accidents of nonfatal accidents/nonfatal accidents	0.650	0.069	0.458	0.811	0.675	0.094	0.343	0.909
Hard-to-diagnose of nonfatal accidents/total accidents	0.330	0.063	0.177	0.475	0.330	0.099	0.083	0.711

Source: EAT

The results of Table A.2. indicate that after implementing the OSH regulation, an increase in the total accident rate, nonfatal accident rate, and the hard-to-diagnose nonfatal accident rate was observed, with increased dispersion of the data. There is a decrease in the fatal accident rate and in the remaining nonfatal accident rate, with a lower dispersion. Regarding the ratios, it is interesting to note the significant increase in the proportion of hard-to-diagnose injuries compared with the nonfatal accidents, as shown in Figure 2. These results reveal the preliminary existence of mixed effects depending on the severity of the accident.

Table A.2. Descriptive statistics of dependent variables if treatment starts in 1997

Variable	Before OSH (1997, 900 observations)				After OSH (1997, 600 observations)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Total accident rate	2997.086	2843.966	100.127	9869.356	3466.117	3160.748	152.593	10399.540
Fatal accident rate	7.371	4.902	0.000	31.264	5.857	3.315	0.000	22.270
Nonfatal accident rate	3134.591	2992.522	94.858	9704.420	3664.546	3376.323	143.956	10754.830
Hard-to-diagnose nonfatal accident rate	922.227	900.028	12.593	3335.274	1430.581	1348.027	38.677	4817.132
Rest of nonfatal accidents rate	2067.785	1972.195	73.778	7463.208	2029.693	1844.895	100.769	6239.662
Fatal accidents/total accidents	0.009	0.011	0.000	0.088	0.006	0.007	0.000	0.041
Nonfatal accidents/total accidents	0.991	0.011	0.912	1.000	0.994	0.007	0.959	1.000
Hard-to-diagnose of nonfatal accidents/nonfatal accidents	0.296	0.065	0.091	0.555	0.401	0.068	0.178	0.657
Rest of Accidents of nonfatal accidents/nonfatal accidents	0.704	0.065	0.445	0.909	0.599	0.068	0.343	0.822
Hard-to-diagnose of nonfatal accidents/total accidents	0.289	0.065	0.083	0.577	0.391	0.069	0.181	0.711

Source: EAT

Table A.3. Most frequent work-related causes in the aggregated dataset depending on the place of accident.

Aggregated accidents					
Global		Treated		Control	
Overexertion	23%	Overexertion	24%	Hits or overrunning by vehicles	50%
Hit by objects or tools	18%	Hit by objects or tools	19%	Falls on the same level	16%
Falls on the same level	10%	Falls on the same level	10%	Fall at different level	10%
Fall at different level	8%	Fall at different level	8%	Slips	6%
Entrapment by/between objects	6%	Entrapment by/between objects	7%	Hit against mobile objects	4%
Total top 5	66%	Total top 5	68%	Total top 5	86%
Total all causes	10,784,027	Total all causes	10,016,523	Total all causes	767,504

Source: EAT

Table A.4. Most frequent work-related accident causes in the nonfatal dataset depending on the place of accident.

Nonfatal Accidents					
Global		Treated		Control	
Overexertion	23%	Overexertion	24%	Hits or overrunning by vehicles	50%
Hit by objects or tools	18%	Hit by objects or tools	19%	Falls on the same level	16%
Falls on the same level	10%	Falls on the same level	10%	Fall at different level	10%
Fall at different level	8%	Fall at different level	8%	Slips	6%
Entrapment by/between objects	6%	Entrapment by/between objects	7%	Hit against mobile objects	4%
Total top 5	66%	Total top 5	68%	Total top 5	86%
Total all causes	10,765,252	Total all causes	10,004,885	Total all causes	760,367

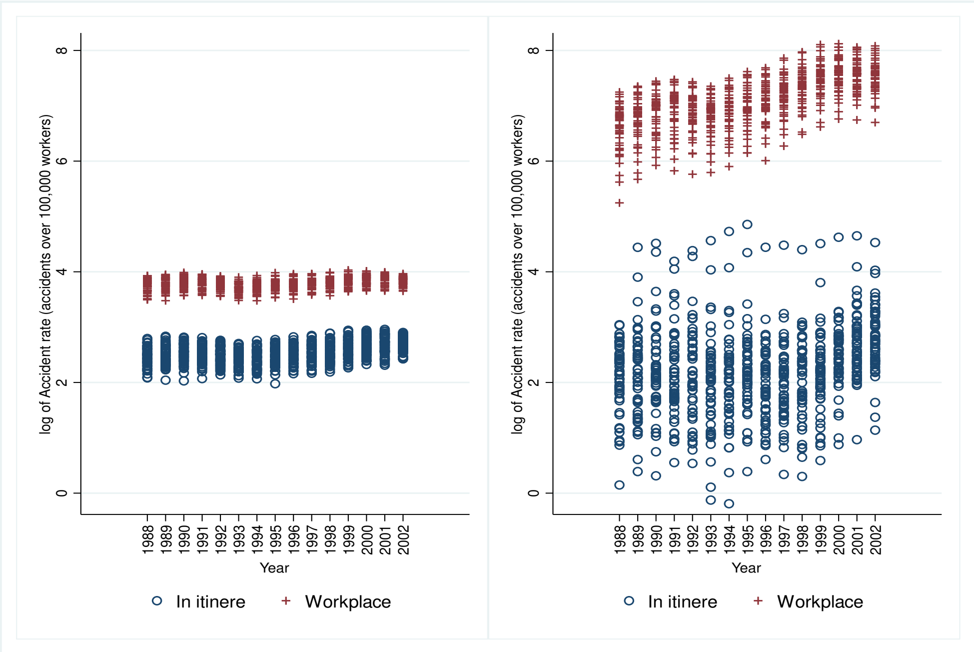
Source: EAT

Table A.5 Most frequent causes of work-related accidents in the fatal dataset depending on the place of accident.

Fatal					
Global		Treated		Control	
Hits or overrunning by vehicles	34%	Non-traumatic pathologies	23%	Hits or overrunning by vehicles	75%
Non-traumatic pathologies	17%	Fall at different level	22%	Non-traumatic pathologies	8%
Fall at different level	14%	Hits or overrunning by vehicles	9%	Hit against non-mobile objects	3%
Entrapment by/between objects	5%	Entrapment by/between objects	8%	Entrapment by machinery overturning	2%
Entrapment by machinery overturning	6%	Falls of objects caused by collapse or demolition	6%	Fall at different level	2%
Total top 5	76%	Total top 5	68%	Total top 5	90%
Total all causes	18,775	Total all causes	11,638	Total all causes	7,137

Source: EAT

Figure A.6 Evolution of the aggregate accident rate (left) and the accident rate caused by overexertion (right)



Source: EAT

Note: The difference in accident rates across groups tended to be smaller in the postregulation period for the general accident rates (left), while it increased for accidents more prone to moral hazard (right). Furthermore, the trend for *in itinere* accidents tend to be more constant, which is logical as they are not affected by the OSH regulation. Finally, the dispersion in the accidents caused by overexertion is higher than in the aggregated specification, which is related to the subjectivity of this cause, which makes it more prone to the presence of moral hazard behaviors.

Table A.7. Impact of the OSH regulation on fatal accidents

Variable	All causes
Log of the accident rate over 100,000 workers	All causes (1)
Constant	2.158*** [0.034]
D	**-0.149**** **[0.044]**
No. observations	1452
R2_adjusted	0.137
legend: * p < 0.05; ** p < 0.01; *** p < 0.001	
Note: Standard deviations in square brackets	

Source: EAT