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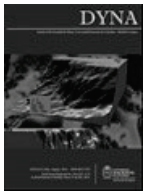

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Occupational injuries in the mining sector (2000-2010). Comparison with the construction sector

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Abstract

This paper compares the incidence of fatal and non-fatal occupational injuries of workers in the mining and construction sectors in Spain between 2000 and 2010. Data on work injuries were obtained from the Spanish Ministry of Labour and Immigration and the denominators were obtained from the available statistics on Social Security registration. We calculated the incidence of fatal and nonfatal occupational injuries, the relative risk (RR) and odds ratio (OR) for a 95% of confidence interval (CI) for the mining workers compared to the construction workers. The obtained results indicate that mining workers have a higher risk of occupational injuries and lost more working days than the construction workers.

Keywords: mining: construction; work injuries; lost working days; fatal injuries

Las lesiones por accidente de trabajo en el sector de la minería (2000 – 2010). Comparación con el sector de la construcción

Resumen

El presente trabajo realiza una *c*omparación entre la incidencia de las lesiones por accidentes laborales mortales y no mortales de los trabajadores del sector de la minería con los trabajadores de la construcción en España entre los años 2000 y 2010. Los datos de lesiones por accidentes de trabajo procedieron del Ministerio de Trabajo e Inmigración y los denominadores se obtuvieron de las estadísticas disponibles sobre afiliación a la Seguridad Social. Se calculó la incidencia de lesiones mortales y no mortales por accidente de trabajo, el riesgo relativo (RR) y la probabilidades relativas (OR) en el intervalo de confianza del 95% (IC 95%) para los trabajadores ambos sectores. Los resultados obtenidos indican que los trabajadores de la minería tienen un mayor riesgo de lesiones por accidentes laborales y de perder jornadas de trabajo respecto a los trabajadores de la construcción.

Palabras clave: minería; construcción; lesiones laborales; jornadas perdidas; lesiones mortales

1. Introduction

The construction sector has been one of the most dynamic in the Spanish economy between 2000 and 2007 and the most studied sector by its occupational accidents [1]. Thus, in 2004 around 106,500 new jobs were created, representing nearly a quarter (23%) of all jobs created in Spain. In this period of time it was common that the amount of buildings that were built in Spain annually exceeded the number of buildings that were built in the whole of Germany, France and the UK [2].

During the period 2000-2010, 2 million people worked in the construction industry, both in buildings and civil engineering works, and specialized construction activities. This amount represents about 10% of the total of the employed population and 7.3% of the gross domestic product [3]. At the same time, the Spanish construction sector had the highest number of accidents resulting in injury with a total of 213,531 cases with time off work [4], excluding in itinere accidents. About 98.9% of them were classified as minor injuries, and caused an equivalent loss of

4.5 million days, or of about 21 days per worker. Musculoskeletal disorders and physical symptoms are common to both activities [5, 6]. Serious injuries caused about 300,000 days of losses [7].

With regard to the mining sector (coal, crude oil, natural gas and non-energetic minerals), the number of employees in the period under consideration was about 60,000. The accidents with time off work were approximately 9,500, producing a loss of 250,000 days, resulting in about 26 days per accident. The incidence of occupational accidents in the Spanish mining sector has been declining throughout the period 2000-2010. However, it continues to have very high values, despite the adoption of several general laws [8,9], and other specific ones for the mining sector to ensure safer working conditions [10,11].

The work in the mining and construction sectors implies a greater risk of death compared to other industries; it is 9 and 3 times higher, respectively [12].

There are many studies on deterministic evaluation of mining and construction sector accidents [13-20] separately. The aim of this study is to evaluate the difference in the risk of fatal and nonfatal occupational injuries of the construction workers compared with workers of mining in Spain between 2000 and 2010.

2. Methods

The assessment of this comparison was based on a study of fatal and nonfatal work injuries occurred in the mining and construction sectors in Spain between 2000 and 2010. Only those injuries in which the injured worker lost at least one day of work were considered. 102,817 non-fatal accidents in mining and 2,348,841 nonfatal in construction and 176 fatal accidents in mining and 2,739 fatalities in construction were found, not including those in itinere [21].

The analysis was performed both for the total work injuries occurred in the construction (National Economic Activity Classification, CNAE 45) and mining sectors. Subsectors of mining considered were: Extraction and agglomeration of anthracite, hard coal, and lignite (CNAE 10), extraction of crude petroleum and natural gas (CNAE 11), mining of uranium and thorium ores (CNAE 12), mining of metal ores (CNAE 13) and non-metallic mining and quarrying (CNAE 14).

The average population per year was calculated as the arithmetic mean of the population at risk that the different surveys (LFS) provided for the years 2000-2010 for each year [22].

The incidence rate of fatal accidents per 100,000 workers, (FR), was calculated according to the formula used by Haile et al. (1) [23].

$$FR = \frac{FN}{ETC} \text{ x } 100.000 \quad (1)$$

Where, FR is the incidence rate of fatal accidents per year in the period 2000-2010, FN, number of fatal accidents in the construction / mining during 2000-2010; ETC, total number of workers in the construction or mining sectors during 2000-2010.

The incidence rate of non-fatal accidents per 1000 workers, (IR), was calculated according to the formula (2).

$$IR = \frac{IN}{ITC} \text{ x } 100.000 \quad (2)$$

Where, IR is the incidence rate of non-fatal accidents per year in the period 2000-2010, IN, the number of non-fatal accidents in the sector under study, and ITC, the total number of workers in the construction or mining sectors during the period 2000-2010.

To calculate the incidence of accidents, we used the number of employees in these economic activities according to the Surveys of Labour Force from 2000 to 2010 and fatal and nonfatal accidents occurred during these 11 years presented by the Spanish Ministry of Labour and Social Affairs [5].

We compared incidence rates of fatal and nonfatal injuries for mining workers respect that of construction workers to determine whether the presence of the risk factor is associated with a higher frequency of lesions (relative risk, RR).

We have contrasted the number of days off work due to nonfatal injuries of mining workers respect to the construction workers. It has been estimated the risk of loss days of work (OR) as follows (3):

$$OR = \frac{Days\ lost\ (mining\ )/Mining\ workers}{Days\ lost\ (construction\ )/Construction\ workers} \quad (3)$$

3. Results

Injuries in mining accidents were quantified by using the incidence rate of accidents of coal mining (CNAE10), petroleum (CNAE11) and non-energetic minerals (CNAE12, 13 and 14). Workers in the coal mines had the largest number of fatalities during 2000, 2007, 2008 and 2009, reaching in year 2000 a total of 17 accidents, having an incidence rate of 73.91 per 100,000 workers (Fig. 1). For all other years higher incidence rates were recorded for workers of the non-energetic mineral extraction, which in 2003 had the maximum of 20 fatal accidents with an incidence rate of 52.22. Oil extraction was the only activity in which for seven consecutive years there have been no fatalities and the highest incidence rate took place in 2006, with 2 deaths, which represented an index of 20.83, although this sector has accounted for 8 to 13% of the total workforce of the mining sector. These data suggest that there is a high degree of occupational safety in this activity (Fig. 1).

Similarly, workers of the coal mining sub-sector, in comparison with the other branches of mining, had a higher rate of fatal injuries for occupational accidents during the 11 years analyzed, peaking in 2008 with 581 accidents. In the oil and non-energy minerals, injuries from accidents are significantly lower than in coal mining.

If we compare the construction and mining sectors, the relative risk of occupational injuries, year by year, on average, it was higher in mining workers, as in the case of non-fatal injuries (1.66, 95% CI: 1.62 to 1.68) as for fatal injuries (2.39, 95% CI: 1.45 to 4), although there are differences in the analysis of the each year (Fig. 2).

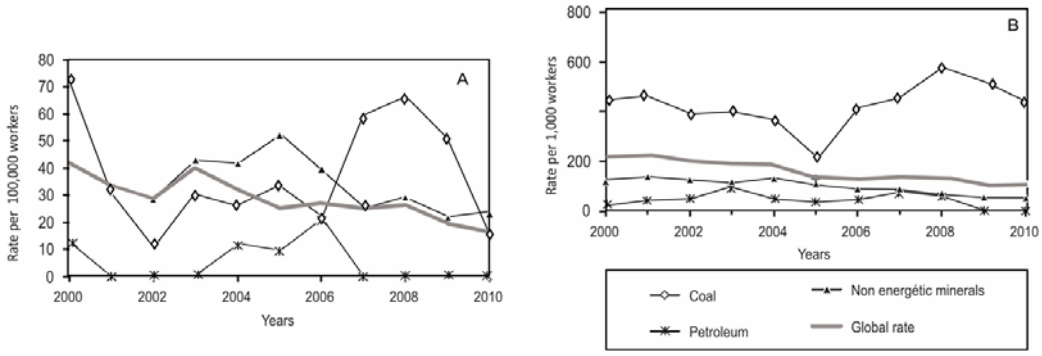

Figure 1. Comparison of the incidence rate of accidents at work in the different mining sectors: (A), fatal, (B), non-fatal.
Source: The authors

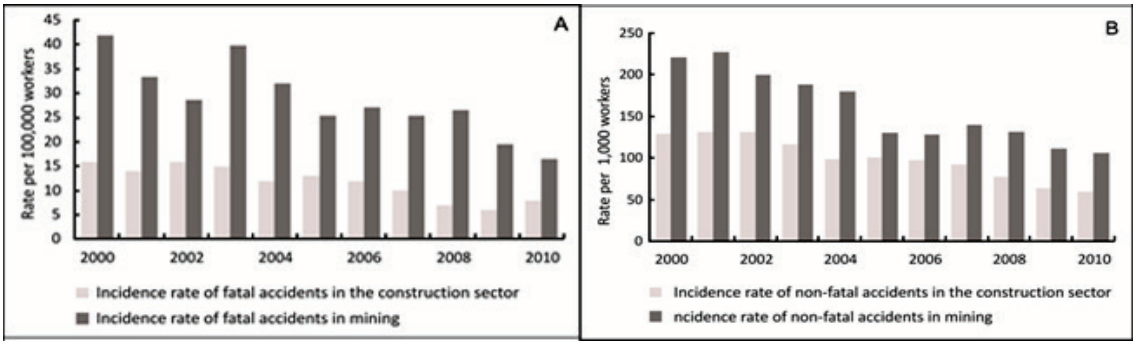

Figure 2. Comparison of the incidence rate of accidents in the mining and construction sectors: (A), fatal, (B), non-fatal.
Source: The authors

The risk of non-fatal injuries by occupational accident was higher for mining workers than for those of the construction sector. This risk was particularly high in 2000 and 2004. Moreover, in 2009, and relatively in 2010, the risk was significantly lower among mining workers. In reference to fatal injuries, every year relative risks occur in mining worker, this was the significant difference in 2000, 2003 and 2006, when these risks exceeded 2.50. Moreover, in the years 2008 and 2009 the risk of fatal injury was almost equal between the two groups of workers. It is noteworthy that in any year the risk of occupational injury among mining workers was lower than that for construction workers (Fig. 2).

To detect if there are common or similar causes in the variation in the accidents rates in non-fatal injuries, these values in the construction and the mining sectors were compared. The evolution of both rates is almost linear, with a Pearson coefficient of 0.84; this suggests that the causes of the temporal evolution of them are similar.

In the case of fatal accidents, despite the linearity of the evolution of both rates, these show a lower Pearson coefficient than in the case of non-fatal accidents (0.78), suggesting the existence of different causes that affect in the evolution of each indicator.

We calculated the incidence rate of accidents of not worked days by occupational accident, as the number of not worked days for this reason, and the population at risk in the related sector. In comparing the days not worked as a result of injuries (Table 1) it can be appreciated that mining workers are at greater risk of losing working days, (1.51, 95% CI: 1.50 to 1.52) almost double that than those in the construction sector, with the consequent economic costs [23-31].

Also we can see that there is a strong linearity between the evolutions of both indicators of workday loss (Table 1), which indicates common driving causes for both indicators.

4. Discussion

This study has been possible solving the common problem in quantitative research of work injuries in the construction and mining sectors in Spain. It is difficult to obtain the number of workers covered by social security, with which to compare properly the number of injuries. This problem is not exclusive of Spain [32]. However, the study is limited, because minor accidents are not reported by the companies, as happens in other countries [33-35], and are not taken into account, so the incidence rates obtained in the present study are lower than the real ones.

The employment in mines is similar to the construction sector; the maximum employment in mines took place in 2006 and in the construction sector in 2007. From these two years the occupation began to decrease in both sectors. In all the mining sub-sectors the fatal occupational injuries have a downward trend, although there is a long way to go to the total elimination of fatal accidents. In coal mining, the rates of fatal accidents are down over the course of the years; the rates of non-fatal accidents decrease rather slowly, from an index of 458 in 2000 to 445 in 2010.

Table 1.
Comparison of lost days (Pearson coefficient = 0.86) for injuries between construction workers and mining workers in Spain, 2000-2010. CI: Confidence interval.

	CONSTRUCTION		MINING			
Year	Lost days	Workers	Lost days	Workers	OR[a]	95% CI
2000	5,190,830	1,850,200	358,293	63,400	2.01	1.99 a 2.03
2001	5,541,976	1,913,200	392,993	63,300	2.07	2.05 a 2.09
2002	5,591,298	1,913,200	341,636	63,300	1.85	1.83 a 1.86
2003	5,364,382	1,984,500	319,601	63,200	1.87	1.85 a 1.88
2004	4,831,552	2,253,200	256,627	59,600	2.01	1.98 a 2.02
2005	5,289,392	2,357,200	235,812	60,300	1.74	1.72 a 1.75
2006	5,493,238	2,542,900	201,271	66,500	1.40	1.38 a 1.41
2007	5,800,105	2,697,300	210,109	50,100	1.95	1.93 a 1.96
2008	4,048,106	2,468,300	164,888	51,900	1.94	1.91 a 1.95
2009	3,262,380	1,911,500	141,053	43,400	1.90	1.88 a 1.92
2010	2,884,399	1,680,000	123,845	41,200	1.74	1.68 a 1.83
Arithmetic mean	4,373,348	2,142,864	249,648	56,927	1.51	1.50 a 1.52

[a] Lost days in mining/Mining workers/ Lost days in construction/Construction workers
Source: The authors

Table 2.
Comparison of the incidence rate of accidents (per 100 000) of fatal injury accidents between workers in the construction and mining sectors in the U.S. and in Spain during 2010.

	USA			SPAIN				
	Deaths	Workers	Incidence rate	Deaths	Workers	Incidence rate	RR	95% CI
Construction	751	5,645,000	13.3	134	1,680,000	8	1.66	1.39 – 2.00
Mining	172	694,000	24.8	7	41,.200	17	1.45	0.68 – 3.10

Source: The authors

The incidence rate of nonfatal accidents per 1,000 workers has been declining in the two sectors considered, through in construction from 129 in 2000 to 60 in 2010 and in the mining sector it decreased from 220 in 2000 to 105 in 2010.

The relative risk (RR) of nonfatal injury for occupational accidents in the eleven years studied was higher in miners, decreasing slightly from year to year, from 1.88 (95% CI; 1.85 to 1.91) in 2000 to 1.71 (95% CI 1.66 to 1.76) in 2010.

Labor legislation and preventive initiatives implemented in the two sectors for the prevention of accidents at work have largely contributed to the reduction of occupational injuries. However, further work is needed on measures to reduce temporary employment or of outsourcing business in Spain, which present higher values than in other European Union countries [36]. Also, the different events that occurred before the occupational injury should be analyzed [37].

Comparing the two sectors it can be appreciated that the relative risk of a fatality is always higher in the mining sector, being almost triple in 2000, with a relative risk of 2.90 (95% CI, 1.98 to 4.30), to nearly equal 1.07 (95% CI 0.34 to 3.35) in 2009. This may be due to the specific characteristics of jobs in the mines, which have worse environmental conditions (high temperatures, presence of gas and dust, high rock-fall hazard in underground mining) and the use of more dangerous machinery and work equipment.

By comparison with the United States of America (Table 2) and analyzing the year 2010 from the queried data of the Bureau of Labor Statics [38], we find that in that year 751 fatal injuries occurred in the construction sector in the USA, respect to 172 in Mining. The employed population in those two sectors was 5,645,000 and 694,000 workers, respectively.

Comparing these data with those from Spain, we can appreciate that in this year the incidence rate of accidents with fatal injuries in the construction sector in Spain was lower than in USA, 8 and 13.3 respectively. Similarly, in mining the rate per 100,000 workers was 17 in Spain, compared to 24.8 in the U.S. The relative risk (RR) of a fatal injury in the USA in construction or mining is higher than in the same sectors in Spain (1.66 in the construction and 1.45 in mining). This suggests that during the Spanish economic crisis, temporary jobs have been reduced, leaving the better informed and trained workers.

The days not worked due to injuries caused by non-fatal accidents have decreased in the two studied sectors throughout the study period. The ratio of days lost in mining per worker was twice the ratio of days lost in construction per worker, over the 11 years studied. This indicates that the non-fatal injury accidents in mines are more serious than in construction and workers need more days to recover.

We also suggest that it is necessary to measure the degree of alcohol and drugs consumed by workers in the workplace as an effective method to reduce accidents, both in construction and in mining, keeping in mind that the reduction of drugs in the workplace has proven to be an effective preventive measure [39].

5. Conclusions and recommendations

The trend of fatal and non-fatal work accidents, both in mining and in construction has declined in Spain during the 11 years analyzed.

The results of the present study confirm an increased risk of work injuries in mining workers with respect to those

from construction. This risk may be higher than that observed if all injuries that occurred were registered.

Within the mining sector, the incidence rate of fatal accidents in coal mining remains high, and constant, regarding the extraction of: oil, metal ores, non-metallic and non-energetic sub-sectors.

The relative risk of a fatal or nonfatal injury in 2010 was higher for workers in the mining and construction in the United States of America than for Spanish workers in equivalent sectors.

Workplace accidents, both in mining and in construction, need to continue being studied in greater detail and with quality data. These studies will make this important health problem visible to the public and, therefore, it will be the first step for prevention.

Both mining and construction companies are required to assess the risks of occupational safety, but often these assessments are not accurate. Consequently, the causes of accidents are not really the same that commonly can be used in other productive sectors. It is imperative to analyze the real causes and get all the information to make a good assessment of risks.

For a better understanding of the nature of the accidents in the analyzed sectors, management should adopt a statistical methodology of accidents nationwide, in each of the sub-sectors of mining and construction. Thus, the studies could be done for each subsector with its own peculiarities, to facilitate planning preventive measures for each [40].

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