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OCCUPATIONAL ACCIDENTS IN MUNICIPAL SOLID WASTE MANAGEMENT (MSW) COMPANIES

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Abstract

The objective of this research was to analyze the factors present in occupational accidents occurred at work among Municipal Solid Waste (MSW) workers. Garbage, and rubbish from household waste were considered as MSW. The study was based on a total of 11,935 accidents occurring and reported in the MSW sector during the period 2009-2012 in Andalusia (Spain), as well as a survey of 572 workers in the above mentioned sector conducted in 2009. All the variables included in the accident reports were analyzed and the possible existence of statistically significant differences between the percentages of each variable category and the severity of the accident were determined. In addition, the results of the accidents reported were compared with the results of the survey for certain variables. Unskilled (Risk Ratio= 7.6) male workers (Risk Ratio= 1.4), aged 25 or below (Risk Ratio= 3.0), with experience of less than one year (Risk Ratio= 12.1), were the ones most susceptible to suffering an accident. In addition, accidents for male workers over 55, occurred in companies with 10 to 24 employees, during the initial hours of the work shift, and caused by loss of control, had the highest probability of being severe or fatal. If the companies considered these risk factors during the design of preventive measures the accident rate in the MSW sector could be reduced.

Key words: Solid waste, management, occupational, safety risk, accident

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1. Introduction

At present, the growing world population and rising consumption are leading to a constant increase in the generation of municipal solid waste. International studies, such as the one presented by the World Bank in 2012, confirm this trend, estimating that in 2025 nearly 2.2 billion tonnes of MSW will be produced (Hoornweg and Bhada-Tata, 2012). In Europe, according to some studies (Mazzanti and Zoboli, 2008), the trend in municipal waste generation has been downward and since 2002 it has remained at approximately 520 kg per capita. Even so, in 2008, over 2,600 million tonnes were produced. Efforts have been made over the last few years to reduce the volume of waste through classification, recycling and composting (CER, 2001). As a result, of the 2,600 million tonnes of waste generated in the EU-27 in 2008, 46% were recycled (Schör, 2011). This was achieved thanks to increases in both the volume of activity and the number of workers in the MSW industry. A good example of this are the data from research conducted by Beck (2001), which estimated that in the United States alone there were over 27,000 public and private organizations employing over 368,000 people (Beck, 2001). Europe is another example, where a study conducted by Ecorys and IDEA in 2009 showed that the industry employs almost two million workers,1,466,673 in waste management and 512,337 in recycling (Ecorys and

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IDEA, 2009). The increase in the number of workers exposed to the risks present in the MSW management industry makes it even more important to adequately manage these risks to limit their impact on workers.

Waste is usually made up of products, materials or objects whose composition and hazards are often unknown. This, together with the fact that society is especially sensitive about this issue, means the sector has to deal with an assortment of problems related to the prevention of occupational risks, making it necessary to increase our understanding of the specific risks in the different jobs (Bunn et al., 2011; Kim and Arama, 2018). This has sparked a great deal of interest given that from an occupational perspective these activities are considered among the jobs with the highest risk of injuries or diseases (Englehardt et al., 2003; Rusu et al., 2017). The health and safety risks for workers managing MSW are caused by multiple factors (Cointreau, 2006), such as the nature of the wastes, their composition, or their management (Battaglia et al., 2015)

Some studies on the sector have been conducted using accident analysis (Bogale and Tefera, 2014) or questionnaires (Ivens et al., 1998) to gather the information needed to limit these risks and which, generally speaking, focused on examining the accidents (Jeong, 2016) and diseases suffered by workers in the MSW industry.

The main results of these studies showed that MSW workers had a high number of accidents, although most of them were minor and related to cuts, perforations and tears, sprains and blows. Moreover, the parts of the body involved were usually the hands and forearms, legs and back (Yang et al., 2001). Fallings from the truck were detected as an important cause of accidents too (Jeong et al., 2015). They usually happens when workers hang from the rear of the truck during transportation or otherwise slip and fall from the truck. In addition, biological risks linked to handling waste were evaluated by some authors (Poulsen et al., 1995a). It is remarkable that high incidence rates of gastrointestinal problems, irritation of the eye and skin, were detected in MSW workers.

Other studies have quantified the scope of the accidents occurred in various countries with regard to their number or incidence. Thus, in Denmark in 1992, the rate of annual occupational accidents in activities related to MSW was 95 out of every 1000 employees compared to 17 for every 1000 employees of the country's total workforce (Poulsen et al., 1995b). In Brazil, a study conducted in 1993 established a rate of 700 accidents a year for every 1000 employees (Velloso et al., 1997). As for fatal accidents, the data from the study conducted in the United States indicated that during the period 1992-97 there was a ratio of 46 deaths for every 100,000 employees (Englehardt et al., 2003). This figure is important, but what is significant is that it is around 10 times greater than the ratio of fatal occupational accidents (Drudi, 1999), with the Bureau of Labor Statistics (BLS) placing it together with the most hazardous occupations: fishing workers, logging workers, airplane pilots, structural iron and steel workers, miners or construction workers.

In relation to Andalusia, although there are no studies on MSW specifically, there is general evidence from the manufacturing industry that there is a higher incidence rate among young workers, workers with only a few months of experience on the job, unskilled workers and male workers (Carrillo-Castrillo et al., 2016). Despite these troubling figures, the number of studies on occupational accidents is much lower for this industry than for other equally dangerous fields such as construction, or the chemical industry (BLS, 2011). Based on the above, the aim of this study was to examine the possible occupational accident risk factors for MSW workers to get an up-to-date and accurate picture of the occupational accident rate in this industry in southern Spain.

2. Materials and methods

2.1. Characterization of the MSW sector in Andalusia

Municipal Solid Waste are responsibility of Municipal governments in Andalusia. They manage the waste collecting and treatment by their selves or through the participation of private companies in public consortiums. The total number of authorized management companies and facilities are summarized in table 1. Waste management system in Andalusia is selective, and household garbage is collected according to four different main categories: Organics, paper, plastic and glass.

Table 1. Distribution of facilities in MSW companies in Andalucia

	Total number
Management entities	45
Facilities	120
Transfer plant	56
Collecting points	23
Landfills	18
Classification and selection plants	23

2.2. Data

This study was based on two sources of information: information from a survey conducted in 21 participating companies in the MSW sector in Andalusia with a sample of 572 workers (the total number of workers of the companies participating in the survey was estimated to be 9,421) (IAPRL, 2011), and information on 11,935 accidents reported by these 21 companies from 2003 to 2012. This companies represent approximately half of the total working population in this sector in Andalusia and the accidents analyzed are also more or less half of the accidents reported in this sector in Andalusia in the period. Summary of accidents happened only in the 21 surveyed companies is showed in Table 2.

Table 2. Summary of accidents in MSW companies surveyed in Andalusia per year

		Year										*Total*
		2003	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	
Severity	Minor	999	1128	1128	1272	1428	1357	1078	1267	1234	911	11802
	Non Minor	6	12	15	22	13	12	16	18	5	14	122
	Total	1005	1140	1143	1294	1441	1369	1094	1285	1239	925	11935

This region has an area of 87,597km^2 (National Statistics Institute, 2011), which is equal to the size of Portugal and larger than countries such as Belgium, Denmark, Austria or Switzerland. In terms of demographics, it has a population of 8,424,102 (National Statistics Institute, 2011) which is equal to the population of Austria and considerably larger than Denmark or Switzerland (Eurostat, 2012).

According to the survey on working conditions in the industry (IAPRL, 2011), 9,421 people were working in the participating MSW companies. The distribution of the sample of workers surveyed in MSW companies in Andalusia, is shown on Table 3. They were selected using simple random sampling technique, after a previous contact with all companies included in official records about MSW companies.

An analysis of the influence of different variables can be done since quality information on the employed population and their working conditions is available. It should be mentioned that in 2009 alone there were 2,334 occupational accidents in this region in all the companies included in this study, which comes to an occupational accident rate of 24,774 accidents for every 100,000 workers. The accident data were obtained from the occupational accident reports submitted to the official accident reporting system in Spain, which is based on the ESAW (Eurostat, 2001) methodology applicable in Andalusia. Accidents reported in Andalusia are collected electronically in "Official Workplace Incident Notification Forms" in the Delt@ information system (Jacinto and Aspinwall, 2004). All accidents that result in an absence from work of one or more days must be reported. In consequence, all accidents occurred and reported in MSW companies from 2003 to 2012 were studied. Relapses, accidents while travelling to work going worksite or backing home ("in itinere") or accidents of self-employed workers are not included. The European Statistics of Accidents at Work methodology phase III (hereinafter, ESAW-III) includes harmonized tools with which to analyze the causes and circumstances of accidents at work.

2.3. Statistical analysis

It is important to note that this research is based in the variables included in ESAW (Eurostat, 2001) so there are other important variables and causes not gathered as it was discussed by Jacinto (2009). This set of variables has been used previously in scientific research (Parejo-Moscoso et al., 2012)

A preliminary analysis covered all the variables included in the accident reports, and contingency tables were prepared for each variable regarding the severity of the accidents. It should be noted that the severity of the accidents was established based on medical criteria with the following levels: minor, severe, very severe or fatal. Given the high number of minor accidents compared to the other categories and to achieve more significant results, severe, very severe and fatal accidents were grouped in a single value. Consequently, severity in the study was considered only at two levels: "Minor" and "Non-minor". Out of all the variables analyzed were ruled out those with no statistical significance, since it was not possible to confirm their dependence with relation to severity and therefore the existence of a significant relationship. The variables selected (Table 4), were classified into the following groups:

- personal: gender, age
- company: type of contract, occupation, workplace, time in the company, size of company, place of accident
- time: day of the week, hours worked
- material: deviation, type of injury, body part involved

The statistical analysis followed the Z-Test method (Comparison of Column Proportions). With this tool it was determined the possible existence of statistically significant differences between the percentages of each category for the variable. In short, a comparison was made to see whether the column percentages varied significantly or not significantly. When looking at the results, the values on the same row and sub-table, but not sharing the same sub-index, were significantly different with $p < 0.05$ in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test. To analyze the data the statistical software SPSS version 21 (Statistical Package for the Social Sciences) was used. Additionally, for the variables for which the necessary data were available, it was conducted a Relative Risk (RR) calculation based on the incidence rates in the various categories. Poisson regression models were used to estimate the rate ratio (RR) and 95% confidence intervals (95% CI), using one of the categories used as a reference (Benavides et al., 2006).

3. Results and discussions

3.1. Gender variable

The results obtained when analyzing the variable gender and accident severity (Fig. 1), showed that the distribution of minor accidents by gender is similar to the distribution of employed workers in 2009 according to the survey (82.9% men; 17.1% women).

Table 3. Distribution of workers surveyed in MSW companies in Andalucia

Categories	***Percentages***			
Gender	**Male**		**Female**	
	82.9 %		17.1%	
Age	**<25 years**	**>25 y <55 years**		**>55**
	1.7 %	91.0 %		7.3 %
Contract type	**Permanent**		**Temporal**	
	83.3 %		16.7 %	
Occupation	**Clerical**	**Qualified**	**Managerial**	**Nonqualified**
	4.0%	4.2%	1.3%	90.5%
Time in the company	**< 1 year**		**>1 year**	
	2.8 %		96.2%	

Table 4. Example of variables included in accidents anonymised

Variables	***Accident #1***	***Accident #2***
Severity	Serious	Light
Gender	Man	Man
Year	2008	2008
Age	45	30
Nationality	Spanish	Spanish
Ocupation	NonQualified	Qualified
Time in the company	3	15
Company size	12	220
Place of the accident	Usual	Not usual
Day of the week	Monday	Friday
Time	10.35	15.45
Hours worked	2.35	7.45
Accident description	Loading waste truck, worker falled	Cutting handling garbage
Material agent	Truck	Waste
Deviation	Fall from height	Cut
Type of injury	Fracture	Wound
Body part involved	Right leg	Left hand

For the rest of the non-minor accidents the column percentages grew significantly for men while they diminished for women. These data indicate that once the accident occurs, the probability of it not being minor is greater in the group of men. As for relative risk, the results were higher among males (RR=1.4) compared to the risk of females considered as the reference category. An explanation for these results may be that the specific tasks and jobs conducted by each gender have a proven impact on the accident ratios (Islam et al., 2011).

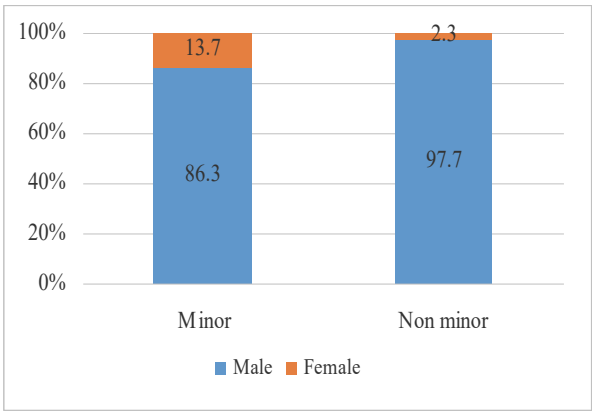

Fig. 1. Accidents in MSW companies comparing gender and severity

Therefore, once the accident has occurred, if suffered by a man, there is more likelihood it will be more severe than if suffered by a woman.

3.2. Age variable

According to the survey, the percentage of employees 25 or younger (1.7%) was lower than the percentage of accident victims (4.8% minor, 4.5% rest), and therefore the relative risk is high (RR =3.0). These results are in line with those found in other more general studies (Salminen, 2004), although the percentage of accidents in this age group was lower compared to a similar previous study on workers in this sector (Bunn et al., 2011) carried out in Kentucky (USA).

Similarly (Table 5), in the group of workers over 55, the relative risk value was higher than one (RR=1.4). In this age group, when comparing the estimated employed population (7.5%), with the percentages of minor (9.6%), severe and fatal (15.8%) accidents, the increase in severe and fatal accidents compared to minor ones was significant. Once the accident took place, it was more likely to be severe or fatal for workers over 55. In contrast, for workers aged 25 to 55, the percentage of accidents (85.3% minor, 78.9% non-minor) was lower than that of the estimated employed population (90.8%), with the

percentage of non-minor accidents being significantly lower than the rest. Then, the safest range is between 25 and 55, with special mention made of workers below 25, as well as those over 55, who showed the worst results, both in incidence, and severity of the accidents.

3.3. Type of contract

Regarding the type of contract (Fig. 2), although workers with temporary contracts have a greater risk of suffering an accident, there were no significant differences in the severity of accidents between those with temporary and permanent contracts. There are several studies which focus on linking workers' temporary contracts to occupational accidents, but so far no evidence has been found of an association between them (Saloniemi and Salminen, 2010).

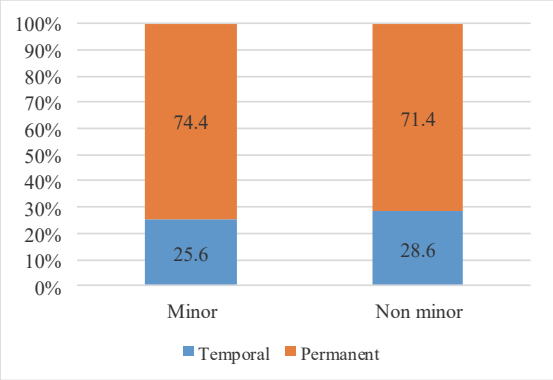

Fig. 2. Accidents in MSW companies comparing type of contract and severity

Although temporary workers suffered a higher percentage of accidents than the estimated population, their severity did not appear to be affected by this variable. Thus, this factor appears to increase the frequency of accidents but not their severity compared to permanent workers.

3.4. Type of occupation

As for the results obtained for the various jobs (Table 6), it was found that unskilled workers had the highest probability of suffering an accident (RR=7.6), and that the likelihood of the accident being severe or fatal, was also higher than for all other jobs studied. Another occupation with worrying results is that of middle managers, for although they have a lower probability of suffering an accident than unskilled workers, the likelihood of a severe or fatal accident is higher.

The occupation variable had no special impact on the severity of the accidents except for the case of middle managers, who had a significantly greater percentage of severe accidents than minor ones. Consequently, this group needs special attention when designing the right preventive measures.

3.5. Type of place of the accident

Results on Fig. 3 show that although accidents outside the usual workplace only amounted to 12.8% of minor accidents, the percentage was almost double that (21.1%) for severe, very severe and fatal accidents.

3.6. Time in the Company

The results in Table 7 show that the probability of having an accident for a worker with less than one year in a company in the sector is more than 12 times greater than for a worker with more than one year of experience (RR=12.1), therefore inexperienced workers are especially vulnerable.

Table 5. Accidents in MSW companies comparing age and severity

AGE	***Severity***						***R.R***
	Minor			***Non minor***			
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***	
No data	41_a	97.6%	0.3%	1_a	2.4%	0.8%	No value
<25 years	570_a	99.0%	4.8%	6_a	1.0%	4.5%	3.0
>25 y <55 years	10062_a	99.0%	85.3%	105_b	1.0%	78.9%	Reference
>55 years	1129_a	98.2%	9.6%	21_b	1.8%	15.8%	1.4

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with p < 0.05 in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test

Table 6. Accidents in MSW companies comparing type of occupation and severity

Occupation	***Severity***						***R.R***
	Minor			***Non Minor***			
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***	
No data	3_a	100.0%	0.0%	0^1	0.0%	0.0%	No data
Clerical	58_a	100.0%	0.5%	0^1	0.0%	0.0%	Reference
Qualified	1896_a	99.2%	16.1%	15_a	0.8%	11.3%	5.8
Managerial	23_a	92.0%	0.2%	2_b	8.0%	1.5%	1.4
Nonqualified	9807_a	98.8%	83.1%	116_a	1.2%	87.2%	7.6

Note: Values on the same row and sub-table,but not sharing the same sub-index, were significantly different with p < 0.05 in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test

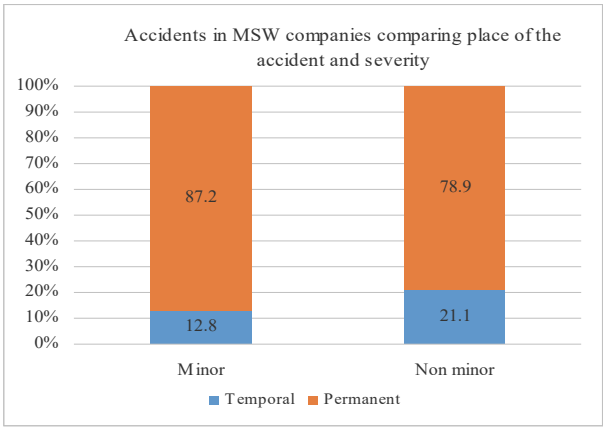

Fig. 3. Accidents in MSW companies comparing place of the accident and severity

These results are in line with those found in another accident rate study which included all production sectors in Andalusia (Bolívar Muñoz et al., 2009). However, when determining the severity of the accident, the variable of time with the company had no significant impact, since all the values on the same row and sub-table share the sub-index. Once the accident occurs, the fact that the workers has worked for the company for a longer or shorter period is not a significant factor in the severity of the accident. The group of workers with less than one year of experience did not exceed 7%, according to the data from the survey (IAPRL, 2011), therefore improving training and communication for workers in this group could be easily addressed by the companies involved. Although the severity of accidents did not vary in relation to time in the company, the incidence was very high among workers with less than one year of service.

3.7. Size of the company

In contrast to time with the company, the size of the company did come up as a significant factor for severity of the accident in the sector (table 8). Several authors have measured the overall influence of this factor in other countries such as Italy (Fabiano et al., 2004), or Denmark (Sørensen et al., 2007) and the general conclusion, without focusing on any specific industry, is that the larger the company, the lower the accident rate.In line with the above studies, the results in this industry in Andalusia evidenced that accidents are three times more likely in companies with fewer than 25 employees than in companies with 25 to 50 workers (RR=3.0).

As for the severity of the accident once it has occurred, companies with 10 to 25 workers varied significantly towards higher severity (1.1% minor; 3.9% non-minor), while companies with 25 to 50 showed significant improvements (3.8% minor; 2.2% non-minor). For the rest of the sizes analyzed, there were no significant differences. Regarding the "size of the company" variable, it was detected that the likelihood of non-mild severity was higher in companies with 11 to 24 workers, while it was least likely in companies with 25 to 50 workers.

3.8. Place of the accident

Although the great majority of minor accidents took place in the usual workplace (81.9%), (Table 9), this percentage diminished substantially as accident severity rose (58.6%). Suffering an accident at a different workplace from the usual one did not appear to affect its severity.

As for traffic accidents, although 35.8% of the workers surveyed worked on a vehicle (IAPRL, 2011), only 5.2% of the accidents reported took place while in service. It is also notable that accident severity travelling to or from work is usually greater than for service-related accidents. It was found that for *in itinere* accidents the percentage of non-minor events tripled the minor ones, while for service-related accidents the increase of non-minor accidents was not statistically significant.

This greater severity in accidents on the way to and from work compared to accidents while in service may have several causes, including the difference between work vehicles, generally of a high tonnage, compared to lighter and more fragile private vehicles, or the greater road safety education of specialised drivers, compared to the average level of road safety education of all company workers who drive to work.

Additional preventive measures in this regard, such as company mobility plans or continuing road safety education for workers, could improve these poor figures, specially "in itinere" accidents.

3.9. Day and time

For the results related to the day of the week shown in Table 10, the highest percentage of minor accidents occurred on Monday (20.7%), similar to the previous results found in a study on MSW workers conducted in Denmark (Ivens et al., 1998), but this percentage decreased gradually over the week.

Table 7. Accidents in MSW companies comparing time in company and severity

Time in the Company	***Severity***						***R.R***
	Minor			***Non Minor***			
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***	
<1.00	3180_a	98.8%	26.9%	36_a	1.2%	27.0%	12.1
More than 1 year	8622_a	98.8%	73.1%	97_a	1.2%	73.0%	Reference

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with $p < 0.05$ in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

Table 8. Accidents in MSW companies comparing time in company size and severity

Company size (staff)	***Severity***					
	Minor			***Non Minor***		
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***
<5.00	14_a	100.0%	0.1%	0^1	0.0%	0.0%
5-10	70_a	98.6%	0.6%	1_a	1.4%	0.8%
11-24	124_a	96.1%	1.1%	5_b	3.9%	3.8%
25-50	446_a	97.8%	3.8%	10_b	2.2%	7.5%
51-250	2922_a	99.1%	24.8%	28_a	0.9%	21.1%
>250	8226_a	98.9%	69.7%	89_a	1.1%	66.9%

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with p < 0.05 in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

For the rest of the accidents, however, the percentage is identical on Mondays, Tuesdays and Thursdays (16.5%), and similar for Wednesdays, Fridays and Saturdays, which suggests the occurrence of the so-called 'Monday effect'. Also noteworthy is that the variation of severity for the same day of the week is not significant except for Saturday, where there is a rising trend (10.0% minor; 15.8% non-minor). The particular hazardousness of Saturdays is even more significant because according to the survey (IAPRL, 2011) over 73% of the staff worked on Saturdays regularly or frequently. Thus, this is not a negligible hazard that affects nearly three quarters of the workers.

For the distribution of the various types of accidents by the length of time the workers had been performing their tasks (Table 11), the highest percentage of minor accidents took place in the third and fourth hour of work (21.4%, and 17.9%). However, most of the non-minor accidents happened in the first hour of work, dropped as the number of hours worked increased, and then picked up again in the eighth and ninth hour of work. Then, the 'Monday effect' present in other sectors also appears to exist for workers in this sector. As for day and time of day, non-minor accidents mostly took place in the first hours of work, which seems to indicate that the key factor here is not fatigue, but rather the proper planning and beginning of the tasks to be conducted.

3.10. Deviation

When comparing the results of deviation and severity (Table 12) the "Loss of control" deviation increased significantly for minor accidents compared to non-minor ones, going from 18.1% to 36.1%. There was a similar increase in accidents caused by the fire or electricity deviation.

On the contrary, the percentage of accidents occurring due to overexertion diminished as accident severity rose. Although no figures were provided to calculate the relative risk, the sector survey (IAPRL, 2011) contributed data on workers' perception of risk. Although the loss of control of machinery was the most severe deviation, this was not specifically contemplated by the workers surveyed.

Table 9. Accidents in MSW companies comparing place of the accident and severity

Place of the accident	***Severity***					
	Minor			***Non Minor***		
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***
usual workplace	9664_a	99.2%	81.9%	78_b	0.8%	58.6%
Not usual workplace	692_a	98.7%	5.9%	9_a	1.3%	6.8%
On the way from worksite-worksite	616_a	98.1%	5.2%	12_a	1.9%	9.0%
In itenere	830_a	96.1%	7.0%	34_b	3.9%	25.6%

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with p < 0.05 in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

Table 10. Accidents in MSW companies comparing day of the week and severity

Day of the week	***Severity***					
	Minor			***Non Minor***		
	Number	***Row %***	***Column %***	***Number***	***Row %***	***Column %***
Monday	2441_a	99.1%	20.7%	22_a	0.9%	16.5%
Tuesday	2069_a	98.9%	17.5%	22_a	1.1%	16.5%
Wednesday	1986_a	99.1%	16.8%	19_a	0.9%	14.3%
Thursday	1815_a	98.8%	15.4%	22_a	1.2%	16.5%
Friday	1737_a	98.9%	14.7%	19_a	1.1%	14.3%
Saturday	1182_a	98.3%	10.0%	21_b	1.7%	15.8%
Sunday	572_a	98.6%	4.8%	8_a	1.4%	6.0%

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with p < 0.05 in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

As for the rest of the risks perceived by workers, in general they had a low perception of risks compared to the values of the deviations causing reported accidents, although the perception of the risk of falling and exposure to substances was quite close to real accident data. It is worth noting that among the deviations causing the accidents reported, loss of control of machinery, falls, as well as fires and electrical faults, had the worst results, although in spite of these bad figures most workers did not appear to perceive these as the main risks in their job, with the exception of the risk of falls. However, based on the risks perceived by the workers in the sector (IAPRL, 2011), and although loss of control of machinery was the most severe deviation, it was not contemplated specifically by the workers surveyed. In spite of the impact that a workers' risk perception may have on the performance of their tasks and on whether they are injured, there are not many studies analyzing this factor. Authors such as Arezes and Miguel (2008) determined that the perception of risk by workers could help predict certain injuries and accidents.

3.11. Type and area of injury

Table 13 shows that in most accidents the type de injury varied significantly in relation to the severity of the accident. In minor accidents the most frequent injury identified was sprains 51.7%. This percentage is similar to the 47.7% found in a previous study on the sector conducted in the United States (Englehardt et al., 2003). For more severe accidents fractures were the most common injury, 44.4%. In relation to the part of the body involved there were no significant differences when comparing the various parts of the body, such as arms, legs, trunk, head and neck, although variations were detected when multiple body parts were affected, with the percentage increasing as severity rises.

4. Conclusions

Accident research does not normally provide information on the population exposed. In this case, a survey conducted in the sector enabled us to obtain details on the incidence rates according to different variables included in the accident reports, as well as to compare the reality of the accidents with workers' subjective perception of certain risks. Accident severity in the field of municipal solid waste is related to different variables covered by occupational accident reports.

Table 11. Accidents in MSW companies comparing length of time the workers at the moment of the accident and severity

Length of time of the workers at the moment of the accident (hours)	*Severity*					
	Minor			*Non Minor*		
	Number	*Row %*	*Column %*	*Number*	*Row %*	*Column %*
0	510_a	96.0%	4.3%	21_b	4.0%	15.8%
1	1703_a	98.9%	14.4%	19_a	1.1%	14.3%
2	2531_a	99.3%	21.4%	17_b	0.7%	12.8%
3	2107_a	99.2%	17.9%	18_a	0.8%	13.5%
4	1602_a	99.0%	13.6%	16_a	1.0%	12.0%
5	1457_a	99.0%	12.3%	15_a	1.0%	11.3%
6	956_a	99.3%	8.1%	7_a	0.7%	5.3%
7	480_a	99.0%	4.1%	5_a	1.0%	3.8%
8	83_a	97.6%	0.7%	2_a	2.4%	1.5%
9	49_a	92.5%	0.4%	4_b	7.5%	3.0%
10	29_a	100.0%	0.2%	0^1	0.0%	0.0%
11	15_a	100.0%	0.1%	0^1	0.0%	0.0%
12	22_a	100.0%	0.2%	0^1	0.0%	0.0%
No data	258_a	96.6%	2.2%	9_b	3.4%	6.8%

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with $p < 0.05$ in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

Table 12. Accidents in MSW companies comparing deviation and severity

Deviation	*Severity*						*(%) of workers who considered it the main risk*
	Minor			*Non Minor*			
	Number	*Row %*	*Column %*	*Number*	*Row %*	*Column %*	
Control Loss	2140_a	97.8%	18.1%	48_b	2.2%	36.1%	No data
Exposure to substances	346_a	99.7%	2.9%	1_a	0.3%	0.8%	2.6
Falls	2008_a	98.8%	17.0%	25_a	1.2%	18.8%	12.4
Fire/Electricity	27_a	87.1%	0.2%	4_b	12.9%	3.0%	0.9
Other	813_a	97.7%	6.9%	19_b	2.3%	14.3%	0.9
Overexertion	3524_a	99.8%	29.9%	6_b	0.2%	4.5%	4.0
Steping/Struck/Strike	2944_a	99.0%	24.9%	30_a	1.0%	22.6%	11.4

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with $p < 0.05$ in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

Table 13. Accidents in MSW companies comparing injury and severity

InjuryType	*Severity*					
	Minor			*Non Minor*		
	Number	*Row %*	*Column %*	*Number*	*Row %*	*Column %*
Amputation	3_a	37.5%	0.0%	5_b	62.5%	3.8%
Asphyxia	3_a	100.0%	0.0%	0^1	0.0%	0.0%
Burns	173_a	96.6%	1.5%	6_b	3.4%	4.5%
Enviroment	12_a	92.3%	0.1%	1_b	7.7%	0.8%
Fractures	509_a	89.6%	4.3%	59_b	10.4%	44.4%
Internal	409_a	98.8%	3.5%	5_a	1.2%	3.8%
Other	465_a	93.8%	3.9%	31_b	6.3%	23.3%
Poisoning/Infection	21_a	100.0%	0.2%	0^1	0.0%	0.0%
Sprain/Strain	6100_a	99.9%	51.7%	5_b	0.1%	3.8%
Strokes	11_a	42.3%	0.1%	15_b	57.7%	11.3%
Wounds/Superficial	4096_a	99.9%	34.7%	6_b	0.1%	4.5%

Note: Values on the same row and sub-table, but not sharing the same sub-index, were significantly different with $p < 0.05$ in the bilateral tests of equality of column proportions. Statistical significance was, thus, 95%. The boxes without sub-indices were not included in the test.

Variables age, occupation, time in the company size of company, place of accident, and deviation showed the more relevant results. Results obtained in current research would help to prevent accidents if they were considered during the design and planning of the preventive measures for workers

4.1. Preventive measures

In general, workplace assessments allows employers to ensure preventive plans to limit or eliminate the risk factors by: selection of adequate working conditions, limited risk exposure, implementation of the proper individual safety equipment's, periodical medical inspection, ergonomic workplace design. In addition, some specific preventive measures in the sector could be summarized as follows:

- To automate waste collection would minimize the exposure of human workers to hygienic and biological risks
- Adequate training and communication adapted to the age of the worker could help improve such negative figures.
- Consideration of variable deviation in the organisation of tasks, or the development of specific training and communication activities for different workers
- Specific procedures, and specific training for the use of dangerous equipment.
- Road safety courses to prevent driving accidents at work.

4.2. Study limitations

For some of the variables studied, the disaggregated percentage of the employed population is not known, therefore part of the results obtained for these variables can only be interpreted taking into account that once the accident occurs, there is a higher or lower probability that the severity will be greater or lesser. It was thus not possible to find the incidence rate or the Relative Risk in all cases.

The study is based on Occupational Accident Reports, therefore data for any accident not reported to the competent labour authorities was not available and was not considered in this study. Occupational diseases were also excluded from these reports.

4.3. Impact on the industry

The main scientific contribution of this research, is a better understanding of the variables present in the accidents occurring in the MSW sector. The results obtained would be very helpful to avoid future accidents, in particular those involving greater severity for the workers.

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