

**Assessment of work-related accidents associated with waste handling in Belo Horizonte
(Brazil)**

Authors:

Marcos Paulo Gomes Mol¹, Amanda Figueiredo Pereira², Dirceu Bartolomeu Greco³, Sandy Cairncross⁴, Leo Heller⁵

Abstract

As more urban solid waste is generated, managing it becomes ever more challenging and the potential impacts on the environment and human health become greater. Handling waste – including collection, treatment and final disposal – carries risks of work accidents. This article assesses the perception of waste management workers in Belo Horizonte, Brazil, in domestic and health service contexts regarding work-related accidents. These are compared with national data from the Ministry of Social Security on accidents involving workers in solid waste management. A high proportion of accidents involves cuts and puncture injuries; 53.9% among workers exposed to domestic waste and 75% among those exposed to health service waste. Muscular lesions and fractures accounted for 25.7% and 12.5% of accidents, respectively. Data from the Ministry of Social Security diverge from the local survey results, presumably owing to under-reporting, which is frequent in this sector. Greater commitment is needed from managers

¹ Fundação Ezequiel Dias / Universidade Federal de Minas Gerais. Belo Horizonte – MG / Brasil. Rua Conde Pereira Carneiro, 80. Gameleira. BH-MG. Brasil. CEP 30510-010. DPD. marcos.mol@funed.mg.gov.br

² Universidade Federal de Minas Gerais (UFMG). Belo Horizonte – MG / Brasil

³ Faculdade de Medicina, Universidade Federal de Minas Gerais. Belo Horizonte – MG / Brasil

⁴ London School of Hygiene and Tropical Medicine. London / United Kingdom

⁵ Centro de Pesquisas René Rachou – Fundação Oswaldo Cruz. Belo Horizonte – MG / Brasil

and supervisory entities to ensure that effective measures are taken to protect workers' health and quality of life. Moreover, workers should defend their right to demand an accurate registry of accidents in addition to monitoring by health professionals trained in risk identification. This will contribute to the better recovery of injured workers and will require managers in waste management to prepare effective preventive action.

Keywords: accidents, occupational risks, solid waste, domestic waste, healthcare waste, occupational accidents registry.

Introduction

As more solid waste is generated, managing it in urban areas becomes more challenging owing to greater potential impacts on the environment and human health. Professionals in solid waste management are considered to be exposed to potential health risks. Their frequent exposure to hazardous materials makes waste collection a potentially unhealthy activity (Poulsen *et al.*, 1995; An *et al.*, 1999; Santos & Silva, 2011). Human contact with waste implies biological, chemical and physical risks to the health of workers involved mainly in waste collection and transportation. Notable factors are associated with exposure to solar radiation, excessive muscular strain, pathogens, such as bacteria, fungi, viruses and parasites, in addition to toxic chemical substances (Rushton, 2003; Wouters *et al.*, 2006; Oliveira, 2007; Domingo & Nadal, 2009).

Other relevant aspects associated with waste collectors' vulnerability to work accidents have to do with the inappropriate conditions in which waste is kept, the type of truck used in collection and the often precarious conditions of public urban roadways (Oliveira, 2007). Furthermore, collection hours often coincide with peak traffic hours, implying risks of traffic accidents with vehicles or personnel (Velloso *et al.*, 1997).

In many developing countries, waste collection is still carried out in precarious conditions. Waste collection professionals generally work outdoors and in direct contact with frequently inappropriately conditioned materials containing sharps and corrosive objects. Excess weight

further increases the risk of muscular injuries in several regions of the body. Moreover, with waste collection often being carried out at high speeds, the risks are high for work accidents possibly involving sharp-related injuries and muscular or spinal cord problems (Silva *et al.*, 2014).

Cleaning staff in hospital facilities report a significant amount of accidents, as demonstrated in several studies (Santos & Silva, 2011; Dias *et al.*, 2012; Blenkharn & Odd, 2008; Vieira *et al.*, 2011; Lima *et al.*, 2011; Giancotti *et al.*, 2014; Borges *et al.*, 2013; Costa, 2007), indicating that locations subject to periodic verifications by sanitary surveillance entities are nevertheless at-risk environments. Urban waste management is even more critical due to the careless way in which waste is deposited by those generating it and by the high speeds at which it is often collected. In sum, workers are exposed to constant danger.

This article aims to assess the vision of waste collection workers in Belo Horizonte, Brazil, regarding their exposure to waste and possible health impacts. It focuses on the accounts of their work accidents as related via a questionnaire. To better apprehend the gathered information, data from the Ministry of Social Security was also compiled on work accidents throughout the country. That data served as a reference for discussion and for possible public health interventions based on the association between work and the health-disease process.

Methods

The methods adopted in this research consist of a questionnaire applied to workers in domestic waste collection and healthcare waste (HCW) collection in Belo Horizonte, Brazil, and data from Brazil's Social Security work accident registry. Sample size calculation was based on the Kelsey model (DEAN et al, 2013) adopting the ratio of eight domestic waste workers for each healthcare waste worker. This ratio was adopted due to the small number of healthcare waste workers in the city where the study took place.

Questionnaires

The structured questionnaires were applied between November 2014 and January 2015 by the researcher and ten other duly trained volunteers. Worker participation in the study suffered losses owing to unwillingness or no-shows on the scheduled dates for interview. In total, 61 workers exposed to HCW and 461 workers exposed to domestic waste participated in the study. Workers were invited to participate in the research study after having been informed on how the structured questionnaire would be applied. With the participants' understanding and consent, each of them filled out an informed consent form (*Termo de Consentimento Livre e Esclarecido* – TCLE in Brazil).

Among the subjects of interest, notable aspects were those related to the occupational conditions of task execution, types of accidents already having occurred while on the job, exposure times and potential impacts on health. Other factors of interest included workers' personal characteristics, such as gender, race, level of education and family income. The research was

carried out in conformity with the ethical requirements determined by the National Research Ethics Committee (CONEP/CNS in Brazil) and were approved by the Research Ethics Committee at the Federal University of Minas Gerais, on 18 June 2014, under protocol CAAE – 28018714.6.0000.5149.

The main criteria for inclusion in the study was the type of activity performed by workers: those considered to be “exposed” handled HCW while domestic waste workers were “unexposed”. All individuals exposed to waste were included independently of how long they had been working, their age or their gender.

The analysis of the questionnaire data was performed with R software, version 3.2.0. For comparison of categorical variables according to the type of waste handled by the worker, the Chi-Square test was applied and also, when necessary, Fisher’s Exact Test (Agresti, 2003).

Occupational accident registration

Work accidents registered with official Brazilian authorities were also used as a source of data. Groups of workers were separated between those responsible for collection and those carrying out treatment and final disposal. The categories of the Brazilian National Classification of Economic Activities (CNAE in Brazil) selected to describe these groups were 3811 (collectors of non-dangerous solid waste, i.e. similar to domestic waste), 3812 (collectors of dangerous solid waste, i.e. flammable, corrosive, reactive, toxic or pathogenic, in accordance with ABTN (2004) standard 10004/2004), 3821 (workers responsible for treatment and disposal of non-

dangerous waste) and 3822 (workers responsible for treatment and disposal of dangerous waste).

Results

Brazil's Social Security data registered a total of 2 152 524 accidents nationwide for all classes of workers in the period between 2011 and 2013. For workers collecting, treating or disposing of domestic and/or dangerous waste, 27 460 accidents were registered nationwide in the same period, representing less than 1% of the total. Only in 2013, with 7 056 registered cases, accidents registered by workers collecting non-dangerous waste were the 14th most frequent type in that year compared to all other registered activities (Brasil, 2015).

The sicknesses and accidents most frequently associated with solid waste management may be estimated by means of the benefits attributed by the INSS, bearing in mind that activities associated with CNAE and cases of underreporting interfere in the representativeness of the results. TABLE 1 presents benefits grants according to their causes. Data related to workers exposed to dangerous waste were not included due to the considerable absence of registered cases.

In addition to the granting of benefits, the incidence of occupational illnesses or accidents were also used as indicators to assess negative impacts on worker health, as expressed in TABLE 2. It may be noted that the frequency of occupational sicknesses observed among workers in non-

dangerous waste treatment and disposal was greater than in the remaining groups in the same periods.

TABLE 1 – Yearly Social Security sickness-assistance benefits granted by some waste-related CNAE in Brazil, according to CID-10 codes selected by the authors, between 2010 and 2013.

Year	CNAE Ref.	CNAE Description	CID Category																						
			A00-B99 ^a		D50-D89 ^b		F00-F99 ^c		I00-I99 ^d		J00-J99 ^e		K00-K93 ^f		L00-L99 ^g		M00-M99 ^h		R00-R99 ⁱ		S00-T98 ^j		TOT		
			Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.	%	Qt.		
2010	38.11-4	Non-dangerous waste collection	73	3.1	7	0.3	284	12.0	166	7.0	35	1.5	275	11.6	53	2.2	492	20.7	5	0.2	598	25.2	2373		
	38.21-1	Treatment and disposal of non-dangerous waste	11	3.0	1	0.3	20	5.4	30	8.1	11	3.0	44	11.9	11	3.0	89	24.1	0	0.0	105	28.5	369		
2011	38.11-4	Non-dangerous waste collection	70	2.5	5	0.2	335	12.0	206	7.4	48	1.7	235	8.4	57	2.0	624	22.3	17	0.6	748	26.7	2800		
	38.21-1	Treatment and disposal of non-dangerous waste	6	1.9	0	0.0	21	6.8	17	5.5	6	1.9	37	11.9	9	2.9	68	21.9	3	1.0	93	29.9	311		
2012	38.11-4	Non-dangerous waste collection	63	2.2	4	0.1	324	11.4	222	7.8	50	1.8	300	10.6	50	1.8	678	23.8	19	0.7	697	24.5	2843		
	38.21-1	Treatment and disposal of non-dangerous waste	10	2.3	0	0.0	23	5.4	30	7.0	7	1.6	76	17.8	4	0.9	69	16.2	4	0.9	152	35.6	427		
2013	38.11-4	Non-dangerous waste collection	47	1.8	1	0.0	326	12.5	180	6.9	43	1.6	251	9.6	34	1.3	693	26.5	35	1.3	566	21.6	2615		
	38.21-1	Treatment and disposal of non-dangerous waste	5	2.6	0	0.0	8	4.2	17	9.0	4	2.1	29	15.3	2	1.1	41	21.7	1	0.5	54	28.6	189		

^a Some infectious and parasitic diseases;

^b Diseases affecting the blood or haematopoietic organs, and some immunologic complications;

^c Mental and behavioural disorders;

^d Circulatory system diseases;

^e Respiratory system diseases;

^f Digestive diseases;

^g Diseases of the skin and sub-cutaneous tissue;

^h Diseases of the musculoskeletal system and connective tissue;

ⁱ Abnormal symptoms, signs and findings in clinical and laboratory exams, not otherwise classified;

^j Lesions, poisoning and other consequences from external causes.

Source: social security statistics; adapted from Brasil (2015).

TABLE 2 – Indicators of occupational accidents for some waste-related jobs in Brazil, between years 2012 and 2013.

Year	Job Ref.	Job Description	Frequency (per 1 000 contacts) ^a	Frequency of Occupational Sicknesses (per 1 000 contacts) ^a	Frequency of typical accidents (per 1 000 contacts) ^a	Frequency of temporary incapacitation (per 1 000 contacts) ^a	Mortality rate (per 1 000 contacts)	Mortality rate (per 1 000 accidents)
2012	3811	Non-dangerous waste collection	60.29	0.45	46.31	53.59	16.84	2.79
	3812	Dangerous waste collection	22.95	0.50	14.62	19.42	25.21	10.99
	3821	Treatment/Disposal non-dangerous waste	64.25	1.19	46.03	58.74	14.04	2.18
	3822	Treatment/Disposal dangerous waste	63.53	0.22	48.92	48.26	-	-
2013	3811	Non-dangerous waste collection	56.71	0.45	43.75	51.15	16.08	2.83
	3812	Dangerous waste collection	33.32	0.44	24.66	25.32	22.21	6.67
	3821	Treatment/Disposal non-dangerous waste	63.17	1.15	45.26	57.97	10.47	1.66
	3822	Treatment/Disposal dangerous waste	50.68	0.37	41.03	40.28	-	-

^a Ratio reflecting the total number of new work accidents each year and the population exposed to the risk of suffering some type of accident (denominator considers the average amount of moments of contact with waste against the number of related, registered work accidents).

Source: social security statistics; adapted from Brasil (2015).

Questionnaire responses

The structured questionnaire that was applied to waste collection workers in Belo Horizonte, Brazil, provided elements to better understand domestic and health service waste collection from the point of view of these professionals. Among the participants, 461 (88.3%) collected domestic waste and 61 (11.7%) collected health service waste. Regarding gender, 21.5% (112) of participants were women and 78.5% (410) were men. Regarding race, 34.2 % (178) declared themselves black, 47.0% (245) brown or mulatto, 2.9% (15) indigenous or metis, and 15.9% (83) white or yellow. Regarding participants' level of education, eight (1.5%) individuals reported illiteracy, while the vast majority, 64.2% (335), had completed primary-level education and 33.7% (176) had completed at least a secondary-level. The median age of participants was 35 years.

TABLE 3 presents a few aspects related to participants' self-reported use of personal protective equipment (PPE). Being the subject of a security standard that is obligatory under national legislation (Brasil, 2015; Brasil, 2005), there may be information bias owing to participants' fear of reporting their own infraction. However, a significant number of accounts nevertheless reported that activities were executed without the appropriate use of PPE.

Regarding the frequency of work accidents, TABLE 4 indicates that 33.2% of workers exposed to domestic waste reported having suffered some type of accident, while this was the case for 26.2% of workers handling HCW. In assessing workers' perception of health-related nuisances, workers were asked if they felt discomfort in a certain part of their body as a result of excess

weight or wear related to their occupation. The information provided indicated that the spinal cord and the inferior members of the body were those presenting the greatest discomforts, while no statistically significant difference was identified between those exposed to domestic waste or HCW.

Risk factors considered to be present in the work routine and potentially harmful to health were also investigated, as presented in TABLE 5. The responses vary, indicating differences in the participants' perspectives. Nevertheless, the available information suggests that some dangers to which workers are exposed are not well recognized.

TABLE 3 – Personal protective equipment use comparison between workers exposed to domestic waste and HCW

Variables		Waste		Value- p
		Domestic N (%)	HCW N (%)	
At least item of one personal protective equipment (PPE) is currently used	No	1 (0.2)	0 (0.0)	1.000 ^b
	Yes	460 (99.8)	61 (100.0)	
Glove	Not used	30 (6.5)	1 (1.6)	0.158 ^b
	Used	431 (93.5)	60 (98.4)	
Boot	Not used	11 (2.4)	0 (0.0)	0.626 ^b
	Used	450 (97.6)	61 (100.0)	
Uniform	Not used	7 (1.5)	1 (1.6)	1.000 ^b
	Used	454 (98.5)	60 (98.4)	
Mask	Not used	420 (91.1)	1 (1.6)	<0.001 ^b
	Used	41 (8.9)	60 (98.4)	
Apron	Not used	443 (96.1)	28 (45.9)	<0.001 ^a
	Used	18 (3.9)	33 (54.1)	
Sunblock	Not used	89 (19.3)	41 (67.2)	<0.001 ^a
	Used	372 (80.7)	20 (32.8)	
Glasses	Not used	380 (82.4)	26 (42.6)	<0.001 ^a
	Used	81 (17.6)	35 (57.4)	
Ear protectors	Not used	426 (92.4)	37 (60.7)	<0.001 ^a
	Used	35 (7.6)	24 (39.3)	

^a Chi-Square Test; ^b Fisher's Exact Test;

Source: questionnaire responses

TABLE 4 – Comparison between perceptions of health disturbances and characteristics of accidents reported by workers exposed to domestic waste and HCW.

Variables		Waste		Value-p
		Domestic N (%)	HCW N (%)	
Already suffered a work accident	No	308 (66.8)	45 (73.8)	0.275 ^b
	Yes	153 (33.2)	16 (26.2)	
Number of times suffering a work accident	1	94 (63.9)	8 (50.0)	0.452 ^b
	2-3	32 (21.8)	6 (37.5)	
	4-7	15 (10.2)	2 (12.5)	
	More than 7	6 (4.1)	0 (0.0)	
	Muscular injury/fracture	39 (25.7)	2 (12.5)	
Type of accident (most recently occurring)	Stick/cut or other sharp	82 (53.9)	12 (75.0)	0.303 ^b
	Traffic	31 (20.4)	2 (12.5)	
	Up to 1 month	22 (15.1)	5 (33.3)	
How long ago most recent accident occurred (in months)	From 2 to 3 months	17 (11.6)	0 (0.0)	0.010 ^b
	From 4 to 10 months	28 (19.2)	7 (46.7)	
	From 11 to 50 months	53 (36.3)	3 (20.0)	
	More than 50 months	26 (17.8)	0 (0.0)	
Did worker go on leave after most recent accident?	No	60 (39.2)	7 (43.8)	0.724 ^a
	Yes	93 (60.8)	9 (56.3)	
Duration of leave (days)	1-2 days	8 (9.2)	1 (14.2)	0.209 ^b
	3-5 days	16 (18.4)	3 (42.9)	
	6-10 days	20 (23.0)	0 (0.0)	
	More than 10 days	43 (49.4)	3 (42.9)	
Was a Work Accident Report made?	No	27 (31.8)	1 (8.3)	0.170 ^b
	Yes	58 (68.2)	11 (91.7)	
<i>Perception of health disturbances</i>		-	-	-
Spinal Chord	No	389 (84.6)	52 (85.2)	0.809 ^a
	Yes	71 (15.4)	9 (14.8)	
Leg	No	402 (87.4)	54 (88.5)	0.801 ^a
	Yes	58 (12.6)	7 (11.5)	
Shoulder	No	432 (93.9)	56 (91.8)	0.525 ^a
	Yes	28 (6.1)	5 (8.2)	
Arm	No	419 (91.1)	57 (93.4)	0.807 ^b
	Yes	41 (8.9)	4 (6.6)	
Hands/feet	No	433 (94.1)	55 (90.2)	0.232 ^a
	Yes	27 (5.9)	6 (9.8)	
Head	No	435 (94.6)	54 (88.5)	0.065 ^a
	Yes	25 (5.4)	7 (11.5)	

^a Chi-Square Test, ^b Fisher's Exact Test;

Variables with totals less than 522 are due to responses not provided by the participants.

Source: questionnaire responses

TABLE 5 – Comparison between perceived risks in routine work of workers exposed to domestic and health service waste.

Variables		Waste		p-Value
		Domestic N (%)	HCW N (%)	
<i>Perceived risks regarding work routine</i>				
Odour	No	189 (41.3)	22 (36.1)	0.437 ^a
	Yes	269 (58.7)	39 (63.9)	
Sound	No	245 (53.5)	35 (57.4)	0.568 ^a
	Yes	213 (46.5)	26 (42.6)	
Dust	No	113 (24.7)	32 (52.5)	<0.001 ^a
	Yes	345 (75.3)	29 (47.5)	
Solar radiation	No	151 (33.0)	35 (57.4)	<0.001 ^a
	Yes	307 (67.0)	26 (42.6)	
Ground with holes or speed bumps	No	201 (43.9)	39 (63.9)	0.003 ^a
	Yes	257 (56.1)	22 (36.1)	
Sharps (needles, glass)	No	144 (31.4)	9 (14.8)	0.007 ^a
	Yes	314 (68.6)	52 (85.2)	
Muscular strain (excess weight)	No	211 (46.1)	25 (41.0)	0.454 ^a
	Yes	247 (53.9)	36 (59.0)	
Chemical substances (oils, cleaning products, medication, etc.)	No	262 (57.2)	12 (19.7)	<0.001 ^a
	Yes	196 (42.8)	49 (80.3)	
Waste with contaminating biological substances	No	207 (45.2)	12 (19.7)	<0.001 ^a
	Yes	251 (54.8)	49 (80.3)	
<i>Report of exposure to liquids in work</i>				
Have liquids (bodily fluids or other) been sprayed in/on your eyes, nose, mouth or skin	No	305 (66.7)	38 (62.3)	0.491 ^a
	Yes	152 (33.3)	23 (37.7)	
Number of times worker entered into contact with liquids	1	22 (15.1)	3 (13.0)	0.229 ^b
	2-5	51 (34.9)	13 (56.6)	
	6-15	14 (9.6)	2 (8.7)	
	More than 15	59 (40.4)	5 (21.7)	

^a Chi-Squared Test, ^b Fisher's Exact Test;

Variables with totals less than 522 are due to responses not provided by the participants.

Source: questionnaire responses

Discussion

Data from Social Security indicate that the granting of benefits is high in Brazil for workers handling non-dangerous waste. Muscular injuries, poisoning and other external causes, damage to the musculoskeletal system and connective tissue account virtually always for more than 30% of the total benefits paid out between 2010 and 2013.

TABLE 1 indicates low rates of benefit disbursements for infectious and parasitic diseases as they represent less than 3% of total benefits disbursed to workers exposed to non-dangerous waste. That information coincides with other research indicating a low prevalence of infectious diseases, relative to the prevalence of occupational injuries, in association with waste management (Rushton, 2003; Porta, *et al.*, 2009).

The benefits disbursed to collectors of non-dangerous waste were high specifically for the injury group comprising lesions, poisoning and other consequences from external causes, these three sub-categories making up 30% of the total. This overall category accounts for a great deal of the most common accidents among waste collectors: those provoked by sharps, traffic accidents or falls from the collection vehicle (Lazzari & Reis, 2011; Ferreira & Anjos, 2001). Such accidents may possibly derive from a lack of training and may be aggravated by high worker turnover and overall inadequate work conditions.

Benefits distributed for diverse damage to the musculoskeletal system and connective tissue were significantly high for workers in the collection, transport and treatment of non-dangerous

waste, accounting for more than 20% of all registered accidents in 2013. That possibly derives from the excessive strain that is inherent to the working conditions. Indeed, some authors assert that lifting excess weight is frequent in waste collection workers' routine and, moreover, that their work rhythm is fast and constant. Other aggravating factors contributing to such stressors include workers' efforts to climb up and down ladders, and the vibration created by collection trucks (Oliveira, 2007; Velloso, *et al.*, 1997; Costa, 2007; Ferreira & Anjos, 2001).

The rate of workers having been temporarily incapacitated from a work accident was higher for workers collecting, treating and disposing of non-dangerous waste than it was for those exposed to dangerous waste (TABLE 2).

For the year 2012, mortality rates (per 100,000 contacts with waste) for the activities of dangerous waste collection, non-dangerous waste collection, and non-dangerous waste treatment/disposal were, respectively, 25.21, 16.84, and 14.04. Those values are greater than the country's total mortality rate for the same year, which was 6.60. The fatality rate for dangerous waste collection was also greater (10.99) than the national average of registered accidents (3.88). In this way, exposure to waste is demonstrably dangerous as compared to non-exposure (Domingo & Nadal, 2009; Porta, *et al.*, 2009; Athanasiou, *et al.*, 2010).

It is complex to determine the representativeness of the findings, mainly owing to high underreporting of work accidents, which is common in several professions in Brazil (Binder & Cordeiro, 2003). Among the possible factors that can influence the rate of accidents with waste

handlers, notable ones are: inadequate training of workers; negligence during the work routine; the informality of this profession; inadequate working conditions and infrastructure. Underreporting of work accidents in Brazil – and worldwide – is frequent, especially for less serious accidents and those occurring in less developed areas (Englehardt *et al.*, 2003; Correa & Assunção, 2003).

Regarding the use of personal protective equipment, 93.5% and 97.6% among those exposed to domestic waste declared that they use gloves and boots, respectively. For those exposed to HCW, those percentages were 98.4% and 100.0%. In a separate research study in Ethiopia, involving waste collection workers in hospital settings, 41.3% of individuals did not use such equipment regularly due to its unavailability or difficulty in using it related to discomfort in the performance of their tasks (Shiferaw *et al.*, 2011).

Differences may be expected regarding the types of protective equipment used by workers handling domestic or health service waste. Domestic waste collectors generally work with trucks and use different equipment than workers who collect HCW. The use of masks and aprons was more common for workers handling HCW and was reported infrequently among domestic waste collection workers. The use of sun block also presented particularities depending on the work hours and where the work activities are carried out.

Liquid splashes during waste collection are another type of danger that workers are exposed to. Among domestic waste collectors, 33.3% declared having been exposed to at least one splash,

while 37.7% of health service collectors declared the same. Similar studies in other countries reported that 23.2% and 27.8% of domestic and hospital waste collectors, respectively, had been exposed to foreign bodily liquids during their work duties (Shiferaw *et al.*, 2011; Luksamijarulkul *et al.*, 2008). Another study focusing on hospital environments identified that 44.0% of workers collecting HCW reported exposure to bodily liquids (Anagaw *et al.*, 2012). Bodily liquids are often found in both domestic and health service waste, and can present a potential risk of infection. Particularly, strains of the hepatitis virus can persist in the environment and a dose capable of causing infection can be very small (Sattar *et al.*, 2001).

Three-hundred twenty-seven (327) reports of accidents were identified among workers exposed to domestic waste and 30 among those exposed to HCW. Considering the average time reported by workers that they had been performing their jobs, it was estimated that accidents occurred at a rate of 70.93 and 70.26 per 1,000 moments of contact with domestic and health waste, respectively. These values are greater than the rates calculated by Social Security in 2013, of 56.71 and 33.2 accidents per 1,000 contacts, for workers handling non-dangerous and dangerous waste, respectively. The differences observed between data from Social Security and the data retrieved via this study may be due to several causes, among which the number of unreported accidents and the possible information bias. Also, it may be noted that waste handlers in health service settings are classified by Social Security as a profession with exposure to dangerous waste. However, this group encompasses other activities as well, which may compromise the comparability of the results.

Studies about occupational safety risks in Floridian (USA) solid waste systems pointed out that the injury rates among refuse collectors in both musculoskeletal and dermal injuries have decreased from 88 and 15 to 16 and three injuries per 1000 workers, respectively. On the other hand, injury rates among recycling workers, for whom musculoskeletal and dermal injuries have increased from 13 and four injuries to 14 and six injuries per 1000 workers, respectively (Bastani & Celik, 2015). Period studied was 2005–2012 compared with historical statistics (1993–1997) (An et al., 1999).

Regarding the data on leave from work due to accidents, worker health appears to be subject to delicate circumstances; 102 (60.4%) individuals who reported a work accident required leave due to the accident. Upon assessing the amount of time that these leave periods lasted, it was discovered that 49.4% and 42.9% of workers handling domestic waste and HCW, respectively, required more than ten days. It may be noted that health service waste handlers incurred a greater amount of accidents in a smaller amount of time as compared to domestic waste handlers, indicating a greater risk of accidents for the former.

Accidents that were not followed up with a CAT (Work Accident Communication) were observed in 31.8% of worker accounts for those exposed to domestic waste and 8.3% of those exposed to HCW; without a statistically significant difference between the two groups. The estimated lack of CAT registries in the state of Minas Gerais and in Brazil as a whole, from 2011 to 2013, was 15% and 10%, respectively (Brasil, 2015). Notwithstanding information bias deriving from workers' fear to disclose potentially compromising information linked to their

jobs, a high number of unregistered work accidents was observed, which may represent the occurrence of accidents for which workers did not seek health care. Moreover, workers often only recognize that a work accident has occurred when they are unable to perform their activities or when a wound presents a large amount of blood.

Injury by sharps

The high percentage of accidents involving sharps – 53.9% among domestic waste handlers and 75.0% among HCW handlers – underscores the danger of being stuck or cut. Muscular lesions or fractures were reported by 25.7% and 12.5% of workers exposed to domestic waste and HCW, respectively. The number of reported accidents is high in both groups of workers. These percentages are worrying as information may still be biased due to workers' fear of disclosing information related to their job. Furthermore, it is noted that due to high turnover many workers had only been working for a short period of time. That may explain why some workers had not reported the accidents, which are common in the activities of waste handlers.

A study performed in Brazil (Velloso *et al.*, 1997) indicated that, among 67 accidents related to waste handling, 50.7% were clinically diagnosed as cuts and wounds, while 34.3% were either a twist or other muscular or lumbar pain. Another study performed in Bangkok, Thailand, indicated that 77.4% of domestic waste collectors reported being victim to at least one cut-stick accident (Luksamijarulkul *et al.*, 2008). A study on hospitals in Ethiopia identified that 19.8% of all accidents among waste collection workers were related to sharps (Shiferaw *et al.*, 2011). In Gondar, Ethiopia, another study indicated that 43.0% of workers collecting health service

waste reported having suffered an accident involving a cut or stick injury (Anagaw *et al.*, 2012). Tsovili *et al.* (2014) found six (28.6%) Anti-HBc (previous contact with hepatitis B virus) positives associated with needlestick accident reported, vs. one (3.4%) unexposed to wastes with a similar accident. Rachiotis *et al.* (2012) found a RR of 2.64 (95% CI=1.01 – 6.96) for the association between reported needlestick accidents and HBV positivity. Similar studies also confirm the danger of sharp-related accidents associated with waste collection (Poulsen *et al.*, 1995; Domingo & Nadal, 2009; Silva *et al.*, 2014; Lazzari & Reis, 2011).

Research studies on healthcare facilities, including on waste collection workers in these settings, have identified the following information linked to sharp-related accidents:

- They represent 46% of all registered accidents (Machado & Machado, 2011);
- 22% are directly associated to contact with waste (Guilarde *et al.*, 2010);
- 87% are associated with biological material (Dias *et al.*, 2012);
- 23% are associated with poorly conditioned sharps in waste (Chiodi *et al.*, 2010);
- 73% of percutaneous exposures, with 14% of these being directly associated to sharp waste (Vieira *et al.*, 2011);
- 16% associated with the inappropriate disposal of sharp waste (Lima *et al.*, 2011);
- 55% of registered cuts and/or sticks during disposal of hospital waste (Özdelikara & Tan, 2012).

Reasons for leave from work indicate that muscular pains account for 39.0% of all participants' reports. The differences between the groups of domestic waste and HCW handlers were not

statistically significant, although the general average value underscores the prevalence of excessive muscular strain that is inherent to this activity, as pointed out similarly in other studies (Oliveira, 2007; Velloso *et al.*, 1997; Costa, 2007; Ferreira & Anjos, 2001).

Risk Perception

In assessing the risks associated with workers' activities, factors such as *dust, sharps, excessive muscular strain, presence of biological material* and *presence of chemical substances* were highlighted in 72.1%, 70.5%, 54.5%, 57.8% and 47.2% of all workers' accounts from the present study, respectively. The difference between workers exposed to domestic waste and HCW was statistically significant for the factors: *dust, solar radiation, ground with potholes and speed bumps, sharps, presence of biological material* and *presence of chemical substances*. The accounts of workers exposed to domestic waste for the risk factors *chemical substances, biological material* and *cuts-sticks* were proportionately less than the responses provided by HCW workers, indicating their little recognition of the dangers associated with waste handling.

A series of precautionary measures are required to protect workers dealing directly with waste, especially given the potential dangers to health to which they are exposed. The elevated frequency with which workers' health is negatively impacted on as a result of their activities appears to have become a trivial set of circumstances, which workers often accept as a part of their routine without having received appropriate warning of the attendant risks.

Limitation

Information presented by workers may still be biased due to interview process, in particular because some qualitative aspects and questions about the past. High turnover can be associated with some workers had not reported any accidents.

Conclusion

In this article, a high rate of accidents was reported by waste workers from Belo Horizonte (Brazil) if comparing with the official information registered by Social Security and scientific publications. In addition, there are indications that work accidents involving waste management professionals in Belo Horizonte may be underreported, especially due to workers' concept of what constitutes a work accident, which is considered only to account for extreme damage to their health.

The research findings suggest that workers would do well to exercise their right to demand that their employers correctly register work accidents via the CAT registry. This measure could contribute to the optimal recovery of victims and to more accurate registers, which may consequently lead to more preventive action being taken by managers in the public hygiene and waste treatment and disposal sectors.

In conclusion, it is important to expand the research body on the relevant occupational risks for waste handlers, with a view to improving their working conditions and quality of life. Furthermore, there is a particular need to increase the representation of this group of often marginalized workers in the context of public policy on sanitation.

Acronyms

A list of acronyms used in this study is presented in TABLE 6.

TABLE 6 – Acronyms list.

Acronym	Definition
CAT	Work Accident Communication
CID	Statistical Classification of Diseases and Related Health Problems
CNAE	National Classification of Economic Activities
HCW	Healthcare Waste
INSS	National Social Security Institute
PPE	Personal Protective Equipment
TCLE	Informed Consent Form

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Financial support provided by the Fundação Ezequiel Dias (Funed), Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

References:

ABNT. Associação Brasileira de Normas Técnicas (2004). NBR 10.004: Resíduos sólidos: classificação [Solid waste: classification], Rio de Janeiro.

Agresti A. (2003). *Categorical Data Analysis*: Wiley. 2nd Edition.

An H, Englehardt J, Fleming L, et al. (1999). Occupational health and safety amongst municipal solid waste workers in Florida. *Waste Management & Research*. 17(5): 369-377.

Anagaw B, Shiferaw Y, Belyhun Y, et al. (2012). Seroprevalence of hepatitis B and C viruses among medical waste handlers at Gondar town Health institutions, Northwest Ethiopia. *BMC Research Notes*. 5:55. doi: 10.1186/1756-0500-5-55.

Athanasiou M, Makrynos G and Dounias G. (2010). Respiratory health of municipal solid waste workers. *Occupational Medicine*. 60(8):618-23.

Bastani M and Celik N. (2015). Assessment of occupational safety risks in Floridian solid waste systems using Bayesian analysis. *Waste Management & Research*, 33(10), 894-907.

Binder MCP and Cordeiro R. (2003) Sub-registro de acidentes do trabalho em localidade do Estado de São Paulo, 1997. [Under registration of occupational acidentes in Brazil, 1997] *Revista de Saúde Pública*. 37(4):409-16.

Blenkharn JI and Odd C (2008). Sharps Injuries in Healthcare Waste Handlers. *Annals of Occupational Hygiene*, 52(4):281–286.

Borges LO, Costa MTP, Filho AA, et al. (2013). Questionário de condições de trabalho: reelaboração e estruturas fatoriais em grupos ocupacionais. [Questionnaire of work condition: elaboration and factorial structure in occupational groups] *Avaliação Psicológica*. 12(2):213-25.

Brasil (2015). Aeps InfoLogo – Base de dados históricos da previdência social [Database of historical social security]. Ministério da Previdência Social [Disponível em: <http://www3.dataprev.gov.br/infologo/inicio.htm>]. Access date: 23/09/2015].

Brasil (2005). Norma Regulamentadora NR 32, de 11 de novembro de 2005 do Ministério do Trabalho e Emprego. Dispõe sobre a segurança no trabalho em serviços de saúde [Brazilian rule about work safety in health services]. Diário Oficial da União, Brasília, 16 nov; 2005.

Chiodi MB, Marziale MHP, Mondadori RM, et al. (2010). Acidentes registrados no centro de referência em saúde do trabalhador de Ribeirão Preto, São Paulo [Accidents reported at the Workers' Reference Center in Ribeirão Preto, Southeastern Brazil]. *Revista Gaúcha de Enfermagem*. 31(2):211-7.

Correa PRL and Assunção AA (2003). A subnotificação de mortes por acidente de trabalho: estudo de três bancos de dados [Under notification of death for work accident: study of three database]. *Epidemiologia e Serviço de Saúde*. 12(4):203-12.

Costa MA (2007). Condições de Trabalho dos Coletores de Lixo Domiciliar, no município do Rio de Janeiro [Conditions of work of the domiciliary garbage collectors, in the city of Rio de Janeiro]. 150f. Dissertação de Mestrado em Engenharia Ambiental do Departamento de Engenharia Sanitária e do Meio Ambiente. Rio de Janeiro: Universidade Estadual Rio de Janeiro; 2007.

Dean AG, Sullivan KM and Soe MM. (2013) OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version. Available at: www.OpenEpi.com (accessed 11 November 2013);

Dias MAC, Machado AA and Santos BMO (2012). Acidentes ocupacionais com exposição a material biológico: retrato de uma realidade [Occupational injury involving exposure to biological fluids: a portrait of reality]. *Revista da Faculdade de Medicina de Ribeirão Preto e do Hospital das Clínicas da FMRP*. 45(1):12-22.

Domingo JL and Nadal M (2009). Domestic waste composting facilities: A review of human health risks. *Environment International*. 35:382-9.

Englehardt JD, An H, Fleming LE, et al. (2003). Analytical Predictive Bayesian Assessment of Occupational Injury Risk: Municipal Solid Waste Collectors. *Risk Analysis*. 23(5).

Ferreira JA and Anjos LA (2001). Aspectos de saúde coletiva e ocupacional associados à gestão dos resíduos sólidos municipais [Public and occupational health issues related to municipal solid waste management]. *Cadernos de Saúde Pública*. 17(3):689-96.

Giancotti GM, Haeffner R, Solheid NLS, et al. (2014). Caracterização das vítimas e dos acidentes de trabalho com material biológico atendidas em um hospital público do Paraná, 2012 [Characterization of accidents at work with biological material and their victims treated at a public hospital in Paraná, Brazil, 2012]. *Epidemiologia e Serviços de Saúde*. 23(2):337-46.

Guilarde AO, Oliveira AM, Tassara M, et al. (2010). Acidentes com material biológico entre profissionais de hospital universitário em Goiânia [Accidents with biological material among professionals working in an university Hospital in Goiania, Brazil]. *Revista Patologia Tropical*. 39(2):131-6.

Lazzari MA and Reis CB (2011). Os coletores de lixo urbano no município de Dourados (MS) e sua percepção sobre os riscos biológicos em seu processo de trabalho [The perception of urban garbage collectors of Dourados, in the state of Mato Grosso do Sul, regarding the biological risks involved in their work routine]. *Ciência & Saúde Coletiva*. 16(8):3437-42.

Lima LM, Oliveira CC and Rodrigues KMR (2011). Exposição ocupacional por material biológico no Hospital Santa Casa de Pelotas – 2004 a 2008 [Occupational exposure to biological material at the Hospital Santa Casa de Pelotas - 2004 to 2008]. *Escola Anna Nery (impr)*. 15(1):96-102.

Luksamijarulkul P, Sujirarat D and Charupoonphol P (2008). Risk behaviors, occupational risk and seroprevalence of hepatitis B and A infections among public cleansing workers of Bangkok Metropolis. *Hepatitis Monthly*. 8(1):35-40.

Machado MRM and Machado FA (2011). Acidentes com material biológico em trabalhadores de enfermagem do Hospital Geral de Palmas (TO) [Work-related accidents with biological material among nursing staff from General Hospital in Palmas, state of Tocantins, Brazil]. *Revista Brasileira de Saúde Ocupacional*. 36(124):274-81.

Oliveira MG (2007). Características organizacionais e acidentes ocupacionais em empresas de limpeza urbana em Salvador-BA [Organizational characteristics of urban waste management companies in Salvador as they relate to the control and prevention of occupational accidents]. 105f. Tese de Doutorado, Instituto de Saúde Coletiva, Salvador: Universidade Federal da Bahia.

Özdelikara A and Tan M (2012). Conditions in which nurses are exposed to the hepatitis viruses and precautions taken for prevention. *Australian Journal of Advanced Nursing*. 30(1):33-9.

Porta D, Milani S, Lazzarino AI, et al. (2009). Systematic review of epidemiological studies on health effects associated with management of solid waste. *Environmental Health*. 8(60).

Poulsen OM, Breum NO, Ebbelohj, N., et al. (1995). Collection of domestic waste. Review of occupational health problems and their possible causes. *The Science of the Total Environment*. 170:1-19.

Rachiotis G, Papagiannis D, Markas D, et al. (2012) Hepatitis B virus infection and waste collection: prevalence, risk factors, and infection pathway. *American Journal of Industrial Medicine*. 2012 Jul;55(7):650-5

Rushton L (2003). Health hazards and waste management. *British Medical Bulletin*. 68:183-97.

Santos GM and Silva LFF (2011). Os significados do lixo para garis e catadores de Fortaleza (CE, Brasil) [What garbage represents for municipal collectors and recyclers in Fortaleza, State of Ceará (Brazil)]. *Ciência & Saúde Coletiva*. 16(8):3413-9.

Sattar SA, Tetro J, Springthorpe VS, et al. (2001). Preventing the spread of hepatitis B and C viruses: Where are germicides relevant? *American Journal of Infection Control*. 29:187-97.

Shiferaw Y, Abebe T and Mihret A (2011). Hepatitis B virus infection among medical waste handlers in Addis Ababa, Ethiopia.(Short Report)(Report). *BMC Research Notes*. 4:479.

Silva DF, Sperling EV and Barros RTV (2014). Avaliação do gerenciamento dos resíduos de serviços de saúde em municípios da região metropolitana de Belo Horizonte (Brasil) [Evaluation of health care wastes management in the metropolitan region of Belo Horizonte (Brazil)]. *Engenharia Sanitária e Ambiental*. 19(3):251-62.

Tsovili E, Rachiotis G, Symvoulakis EK, et al. (2014) Municipal waste collectors and hepatitis B and C virus infection: a cross-sectional study. *Le Infezioni in Medicina*, n. 4, 271-276, 2014.

Velloso MP, Santos EM and Anjos LA (1997). Processo de trabalho e acidentes de trabalho em coletores de lixo domiciliar na cidade do Rio de Janeiro, Brasil [The labor process and work-related accidents among garbage collectors in Rio de Janeiro, Brazil]. *Cadernos de Saúde Pública*. 13(4):693-700.

Vieira M, Padilha MI and Pinheiro RDC (2011). Análise dos acidentes com material biológico em trabalhadores da saúde [Analysis of Accidents with Organic Material in Health Workers]. *Revista Latino-Americana de Enfermagem*. 19(2).

Wouters IM, Spaan S, Douwes J, et al. (2006). Overview of personal occupational exposure levels to inhalable dust, endotoxin, $\beta(1\rightarrow3)$ -glucan and fungal extracellular polysaccharides in the waste management chain. *Annals of Occupational Hygiene*. 50(1):39-53.