

Use of capture-recapture method to improve the notification of fatal occupational injuries records in Belo Horizonte city, Minas Gerais State, Brazil, 2011

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Abstract

Objective: to measure underreporting of typical fatal occupational injuries (FOI) on the Mortality Information System (SIM) in Belo Horizonte city, Minas Gerais State, Brazil, in 2011. **Methods:** the capture-recapture method was used to assess all FOI recorded among city residents and/or occurring in the city, using probabilistic linkage of three data sources: SIM, the Notifiable Diseases Information System (SINAN) and the Belo Horizonte Forensic Medicine Institute Autopsy Database. **Results:** the majority of the 54 cases found occurred in males (n=53), with drivers and construction workers accounting for half of them (n=28); the most common causes of death were traffic accidents (n=18) and falls (n=10); 15 deaths were underreported on SIM. **Conclusion:** the use of the capture-recapture method contributed to the detection of FOI underreporting.

Keywords: Information Systems; Occupational Health; Occupational Mortality; Forensic Medicine.

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Introduction

Deaths due to occupational injuries are a serious Public Health issue in Brazil and all over the world. Occupational injuries can be defined as 'typical', if they happen during the work activity, and as 'commuting', if they happen during a person's commute to or from work.¹ In 2010, there were around 350 thousand work-related deaths in the world.^{2,3} This is a relevant amount, mainly if we consider the possible underreporting, especially in developing countries.⁴ According to the International Labour Organization (ILO), also in 2010, around 18 thousand deaths occurred in American low and middle income countries – including Brazil.³

Although one of SIM's objectives is to fully cover deaths in Brazil, it is almost impossible to determine the number of deaths due to occupational injuries that are not recorded on this system.

In Brazil, the workers with formal work contracts under the Consolidation of Labour Laws (*CLT*) are submitted to the General Social Security Policy. All fatal occupational injuries covered by the Work-related Injury Insurance (*SAT*) should be reported to the Ministry of Social Security (*MPS*), through a form called Communication of occupational injury (*CAT*). In 2010, more than 2,800 occupational deaths were reported to the *MPS* system.⁵ Also according to social security data, mortality rates due to work-related injuries fell from 14.9 in 1998 to 7.7 in 2006, per one thousand workers.⁶ On the other hand, in São Paulo state, there was an increase in the fatality rate of almost six times, raising from 0.18% in 1970 to 1.07% in 2003.⁷ The increase in fatality rate and the reduction the numbers of deaths may point to underreporting by the *MPS*.⁷ Moreover, it is noteworthy that public employees, domestic workers and informal workers are not covered by the *SAT*. The absence of *SAT* coverage for these workers restrains the real dimensioning of the epidemiological situation of cases in the country and can impact in the planning of actions focused on its control.⁷⁻¹¹

The notification of fatal occupational injuries is part of one of the attributions of the Ministry of Health that uses a specific notification form as source to feed the Information System for Notifiable Diseases

(*Sinan*). When these injuries result in death, they are notified in the Mortality Information System (*SIM*), by using the Death Declaration (*DO*), which presents an specific field that relates the death to the occupation.⁹⁻¹² Both systems are fed by the Municipal Health Departments (*SMS*), are considered universal and mean great advance in capturing cases not registered by the *MPS*, although they still present underreporting issues.¹⁰⁻¹³

Although one of *SIM*'s objectives is to fully cover deaths in Brazil, it is almost impossible to determine the number of deaths due to occupational injuries that are not recorded on this system. The routine data recovery, from different information sources, may be a strategy to minimize the problem. Analyzing the relation between the register of serious occupational injuries on *Sinan* and deaths on *SIM*, as well as continuously evaluating other information systems in the Workers' Health area (*MPS*) has been a feasible action, considering that some authors have succeeded in identifying non reported cases by using these means.^{10,12,13}

The search of these absent events from the systems of compulsory notification, conducted through investigation in police sources and verbal autopsy, for example, is another form, although less common, of reducing the underreporting of fatal occupational injuries.^{14,15} An easy and low cost option is to estimate underreported cases using the capture-recapture method. This method consists on searching common and exclusive data on independent information sources, in order to enable the underreporting evaluation in each one of the databases, the total collection of cases and the correction of databases.^{16,17}

The objective of this study was to measure underreporting of typical fatal occupational injuries (FOI) on the Mortality Information System (*SIM*) in Belo Horizonte city, Brazil, in 2011.

Methods

This is a descriptive study using capture-recapture method, in order to comprehend the total FOI reported in Belo Horizonte (BH), whenever this city was the place of the incident and/or place of residence. This method was chosen due to its simplicity and easiness to perform, and it was used in the past used to estimate the population of France and the size of wild animals' populations. This method can also

be used in epidemiological researches, because it allows the usage of incomplete information sources through records overlap to measure underreporting of each system.¹⁶ The method's requisites were reached for this study:¹⁷ closed population (deaths of BH residents and/or that occurred in that city in 2011); unequivocal records (death); each individual presented the same probability of belonging to each sample (equiprobability); in each data source the case was captured independently from the others; and the search was performed in independent data sources (each of them considering a population sample) – *SIM*, *Sinan* and the Belo Horizonte Forensic Medicine Institute Autopsy Database (*BNIML/BH*). The records identifier for pairing the cases was formed based on the combination of at least two of the following attributes: full name, birth date, and mother's name. We considered as case captured the FOI registered on *SIM*; and as case recaptured, those registered only on *Sinan* and/or *BNIML/BH*.

According to the 2010 Demographic Census, in that year, BH had a population of 2,375,151 people and the population density was 7,167. There were 1,590,502 employed people in the city and the human development index was considered high (HDI=0.810), although the city presents areas of agglomeration and extreme poverty.¹⁸ 2011 was the chosen year in order to resume another study.¹²

The FOI which occurred in the city were processed on *SIM* and *Sinan*. On *SIM*, the cases of BH residents who died in other cities composed the municipal base through a feedback process. The BH Forensic Medicine Institute (*IML/BH*) conducted autopsy examinations of FOI which occurred in BH and in cities from the metropolitan region, except for Betim-MG. Therefore, the sources used in this study contain information of deaths of residents in BH, deaths occurred in BH and in other cities.

The deaths selection followed the steps below:

- 1) on *SIM*, all deaths with the field 49 of the *DO* (question: Was it occupational injury?) filled in the option 1 (Yes) were considered to be cases;
- 2) on *Sinan*, the cases selected were the ones with the item 1 (typical) of the field 55 (Type of accident) of the notification report filled, when it was specified that it referred to a typical occupational injury, and also the item 5 (death due to occupational injury) of the field 66 (case outcome), about fatal cases; and

- 3) on *BNIML/BH* a keyword search was conducted in the field/form 'Records' of the autopsy reports, such as 'occupational injury', 'workplace', 'construction area', 'within the company', 'within the construction', 'fall from scaffolding', 'within the workplace' and small variations of these expressions, for example, 'within construction'; all the autopsy reports were written by the coroner, using Word®; each report had various defined fields (form's type), which were exported to Excel®; each report represented one line on Excel®, and its fields/forms were presented in the columns; one of the fields/forms contained information on the 'Records' of the occurrences, and the search for keywords was conducted on this column.

To ensure the data integrity, the researchers double-checked the *DO* and the autopsy reports. To solve doubts concerning the characteristics of the FOI in each one of the sources, the medical reports were used for complementary information. Cases in which FOI information was incorrect or inconclusive were excluded. Commuting occupational injuries were also excluded, because typical injuries are more specific and have less underreports.¹⁹

The variables studied were:

1) Characteristics of the injured

- sex (female; male)
- marital status (single; married; divorced; widow)
- ethnicity/skin color (brown; white; black)
- education level (incomplete elementary school; complete elementary school; incomplete high school; others)
- age, in age groups (15-24; 25-34; 35-44; 45-54; 55-64; 65-82)
- occupation groups (construction workers; drivers; customer service workers; manufacturers of metals and composites; others)
- situation of the injured in the job market (formal contract under the Consolidation of Labour Laws [*CLT*]; others)

2) Characteristics of the accident

- city of residence and of death occurrence (Belo Horizonte; others)
- place of death (urban streets; facilities of others; employer facilities)
- time of death (same day of the accident; days after the accident)
- medical care (yes; no)

- cause of the accident (traffic accident; fall; exposure to mechanical force; aggression; electric shock; others)

Not all the variables/categories were available on the three studied sources. In cases of information divergence, information from *SIM* was considered.

The software R was used (version 3.0.1) for data description and to obtain central trend measures.

The research was approved by the Research Ethics Committee of the Municipal Health Department of Belo Horizonte (*SMS/BH*) – Register No. 0002.0.410.000-11 – and was conducted according to the National Health Council Resolution No. 466, dated 12 December, 2012.

Results

Of the 43 FOI cases recorded on *SIM*, 4 were excluded (Figure 1): 2 for not being occupational injuries and 2 for being inconclusive about the type of accident (typical or commuting). All the 46 cases recorded on *Sinan* were considered eligible. Of the 39 cases obtained from the *BNIML/BH*, 2 were excluded for being inconclusive concerning the characteristic of the occupational injury and 10 for not having occurred in BH or the person not being resident in that city (Figure 2).

After applying the capture-recapture method, the final database was composed of 54 cases of FOI: 25 victims lived in BH and 29 in other cities (Table 1).

Among the 25 deaths of BH residents, having occurred or not in that city, 16 were registered on *SIM*, 22 on *Sinan* and 12 on *BNIML/BH*. Of the 9 cases that were not recorded as FOI on *SIM*, 5 were

captured only through *Sinan* due to the impossibility of linking the death due to aggression to work on *SIM* (Table 1). The other 4 cases did not occur in BH: 3 were captured by the *BNIML/BH* and 1 by *Sinan*. The underreporting of these cases happened because of the lack of connection between the death and the work by the city of occurrence. On *Sinan*, 3 FOI were not recorded and were captured by the *BNIML/BH*. With regard to the *BNIML/BH*, 13 cases were underreported: 7 of them occurred out of BH and the autopsy did not happen in the capital (6 were exclusively captured by *Sinan* and 1, by both *SIM* and *Sinan*), 5 were related only to aggression (registered only on *Sinan*) and 1 was considered commuting (notified by both *SIM* and *Sinan*) (Table 1).

The 29 FOI of residents of other cities that happened in BH were registered as follows: 23 on *SIM*, 24 on *Sinan* and 15 on *BNIML/BH*. Of the 6 cases not captured by *SIM*, 3 were only on *Sinan*, 2 were only on *BNIML/BH* and 1 was on both *Sinan* and *BNIML/BH*. 3 cases could not be registered as FOI on *SIM*, because they were aggressions related to work (Table 1). *Sinan* presented 5 underreported cases: 1 was captured only on *SIM*, 2 only on *BNIML/BH* and 2 on both *SIM* and *BNIML/BH*. There were 14 underreported cases on *BNIML/BH*: 10 were registered on both *SIM* and *Sinan*, 1 only on *SIM* and 3 only on *Sinan*. Of these 14 cases, 3 were related to aggression and 7 to traffic injuries.

Of the 54 cases, only one victim was female and 30 had brown skin color. The average age was 41.81 years old (standard deviation [SD]=12.96; coefficient of variation [CV]=0.31, and only 6 individuals had completed elementary school (Table 2). About one third of the individuals were aged between 45 and 54

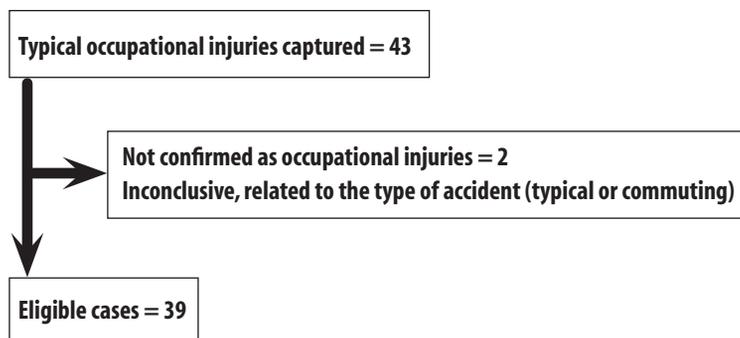


Figure 1– Flowchart of the selection of deaths due to occupational injuries on the Mortality Information System (SIM) in the city of Belo Horizonte-MG, 2011

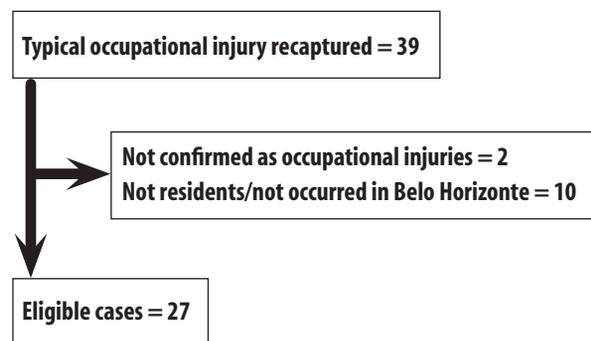


Figure 2– Flowchart of the selection of deaths due to occupational injuries on the Forensic Medicine Institute Autopsy Database in the city of Belo Horizonte-MG, 2011

Table 1 – Number of deaths due to occupational injuries before and after the use of capture-recapture method, according to information source and city of residence, occurred in Belo Horizonte-MG and in other cities, 2011

Use of capture-recapture method	Source	Deaths of Belo Horizonte residents		Deaths of other cities residents	
		Occurred in Belo Horizonte	Occurred in other cities	Occurred in Belo Horizonte	Occurred in other cities
Before	SIM ^a	10	6	23	–
	BNIML/BH ^b	9	3	15	–
	Sinan ^c	15	7	24	–
	Total	15	10	29	–
After	SIM ^a	10 (*5)	6 (*4)	23 + 3 (*3)	–
	BNIML/BH ^b	9 + 6	3 (*7)	15 + 14	–
	Sinan ^c	15	7 + 3	24 + 5	–
	Total	15	10	29	–

a) SIM: Mortality Information System

b) Sinan: Information System for Notifiable Diseases

c) BNIML/BH: Belo Horizonte Forensic Medicine Institute Autopsy Database

Subtitles:

+ number = number of cases added to the information source (and were not in the initial data of the mentioned source).

*number = number of cases that should be added to the information sources (and were not in the initial data of the mentioned source).

years and almost half of them were single. Drivers and construction workers accounted for more than half of the victims, and 27 of 31 victims worked with formal contracts under the *CLT*.

The most common causes of death were traffic accidents (one third of the cases) and falls (one fifth of the cases) (Table 3). Most deaths occurred on the same day of the accident (32 cases) and on urban streets (20 cases). Among the 34 victims who did not die at the accident scene, only one did not receive medical care in a reference hospital of the metropolitan region. The average time between the accident and the death was three days.

There was FOI underreport related to traffic accidents (15/18 cases), aggressions (8/8 cases),

drivers deaths (13/14 cases) and customer service workers (9/9 cases) on *BNIML/BH*. Incompleteness was observed for the following variables: 'marital status' (1 case), 'skin color' (5 cases), 'situation in the job market' (23 cases) and 'place of death' (5 cases).

Discussion

Data available on electronic databases were used, and this would allow the method's application to qualify these information sources, bases of the Workers' Health surveillance in Brazil. The capture-recapture allowed the identification of underreport of 15 of the 54 FOI on *SIM* and 8 on *Sinan*. Most of the victims were men, single, brown-skinned, aged 45 to 55 years old, and had

Table 2 – Characteristics of the victims of typical occupational injuries in the city of Belo Horizonte-MG, 2011

Characteristics	N
Sex (n=54)	
Male	53
Female	1
Marital Status (n=53)	
Single	25
Married	16
Divorced	8
Widowed	4
Ethnicity/Skin color (n=49)	
Brown	30
White	14
Black	5
Education level (n=54)	
Incomplete elementary school	39
Complete elementary school	6
Incomplete high school	7
Others	2
Age group, in years (n=54)	
15-24	8
25-34	10
35-44	12
45-54	15
55-64	8
65-82	1
Occupation groups (n=54)	
Construction workers	14
Drivers	14
Others	11
Customer service workers	9
Manufacturers of metals and composites	6
Situation in the job market (n=31)	
Formal contract under the CLT ^a	27
Others	4

^aconsolidation of labour laws

low education level. Among the FOI, the most common accidents were: traffic accidents; on urban streets; involving drivers; construction workers; and individuals with formal contracts under *CLT*. Usually, the event occurred outside the company and the death happened the same day of the accident. On *SIM*, underreporting occurred for all the homicides and for 25% of deaths of BH residents that happened in other cities.

Underreporting on *SIM* was mainly related to the current impossibility of this system to notify deaths due to aggression, when these are related to occupational activities, and this is a major failure:⁹ if *SIM* presented

the possibility to include these notifications, in BH, for example, the underreporting would drone in one third (5 of 15 cases). Other underreport causes were (i) difficulties on exchanging information between the cities of residence and of death occurrence and the (ii) major incompleteness of the variable that relates the death to the work in the *DO*.¹⁹⁻²⁰ These issues could probably be solved with investments on improving the information flow between the cities of residence and of occurrence, training and stimulating the staff responsible for filling the *DO* and the death investigation teams, and a bigger union between

Table 3 – Characteristics of the typical occupational injuries in the city of Belo Horizonte-MG, 2011

Characteristics	N
Place of death (n=49)	
Urban streets	20
Facilities of others	20
Employer's facilities	9
Time of death (n=54)	
Same day of the accident	32
Days after the accident	22
Medical care (n=54)	
Yes	34
No	20
Cause of the accident (n=54)	
Traffic accident	18
Fall	10
Exposure to mechanical force	9
Aggression	8
Others	5
Electric shock	4

SIM managers and Workers' Health surveillance.²¹ The limitation in capturing these deaths may also be connected to problems in the *DO* flowchart (at registrars and *IML*, for example), irregular cemeteries (where burials without necessary documents are possible) and flaws on the integration of the municipal health managers.²²

The use of *IML/BH* data contributed to a raise of 5 FOI on *SIM* and *Sinan*, appearing as an alternative to cases confirmation during routine investigation conducted by the Municipal Health Department (*SMS*). Police records have already been used – successfully – in the Rio de Janeiro state, in a research on work-related deaths.^{14,15}

In this study, the higher underreport was found on *BNIML/BH*, concerning traffic accidents and aggressions. This finding reinforces the need to change a wrong but persistent perception in which occupational injuries would only be those that happen inside the company, and this could allow a more effective surveillance through training actions.¹⁴⁻¹⁵

For being preventable and avoidable deaths, the number of FOI found shows a vulnerability of work conditions, still not solved by the current laws in the country.¹⁶ With regard to the victims profile, other researchers have found similar results to this study: adult men,^{9,12,19,20} with lower education level^{9,12,19} and brown-skinned.¹⁹ Typical traffic injuries and falls are

the main causes of death, related to the occupation of driver and construction worker, respectively. It is known that the relation between the most common accidents and occupations may vary according to the studied region, productive profile, risk exposure, informality on work relations, existence or not of vulnerable groups, and other specific characteristics related to each population.^{8,23} Local studies are necessary to better understand the profile of each region and to establish specific strategies aiming at handling occupational injuries.²³

Deaths due to aggression and traffic accidents among workers point to the relevance of urban violence in Brazil and the expansion of occupational environment, much beyond the companies' rooms, reaching the streets and the facilities of other people.^{9,19,24-25} The proportion of deaths due to aggression related to work, similarly to what was described by other authors, shows the severity and complexity of a problem that requires multilateral intervention. In the metropolitan region of Campinas, São Paulo state, a research on data of the National Social Security Institute (*INSS*) related to the period 1979-1989 related 9.2% of deaths due to occupational injuries to homicides.²⁴ According to *INSS* and *DO* data of the 1997-1999 period, this proportion was of 18.8% in São Paulo state; in a sentinel unit in Curitiba, Paraná state, it was 12% (2006 to 2010); and according to Salvador *IML*, in Bahia state, it was 37.3% in 2004.^{9,19,25}

Although these studies have adopted different methods, all of them point to a common evidence: the magnitude of homicides related to work in Brazilian big cities. In BH (2011), the proportion of occupational injuries related to homicides was 14.8%, slightly higher than the 13% found to the same city between 2008 and 2010, when only *SIM* and *Sinan* data were used.¹²

A limitation concerning the results presented in this study is that the conclusions should be cautiously interpreted because the data analyzed were obtained from a specific region, with singular investigation flow, comprising only a one-year period. There are some singularities of the *SMS/BH* on searching and identifying FOI cases, such as the communications of occupational injuries – *CAT* – as main source of investigation of cases registered on *Sinan*, to which can be added the active search on the Internet, in trauma reference hospitals, and in the *IML*, and the continuous data crossing between *SIM* and *Sinan*.¹² Another fact to be considered is that, regardless of the *IML* belonging to the state, there are administrative singularities related to how it works in the different Brazilian states, which can affect the access, by the various *SMS*, to data related to FOI search. Particularly, the *IML/BH* is attached to the Civil State Police and has objective flow, allowing and favoring investigation of deaths by the *SMS* staff. *Sinan* has showed to be the most important information source to capture cases; however, we observed that most notifications referred to formal workers under the *CLT*, and this fact limited the understanding of risks related to occupational activities of a great amount of workers not covered by the Work-related Injury Insurance (*SAT*). To reach all the workers, the sentinel units of notification (Reference Centers in Workers' Health [Ceresst]; reference hospitals in urgency and emergency care and/or medium and high complexity care; primary and medium complexity health care accredited as sentinels), must be encouraged to intensify its performance, enriching the registers' correction. In FOI cases, notification is mandatory in these sentinel units, and is to be performed by any health professional, and also by the responsible staff for those establishments.²⁶ The inclusion of new notifiers sentinel units, such as the *IML*, could also contribute hugely to reduce underreporting.⁸ The flaws in reporting may be related to the employers, to the employee and/or the health professional who received the injured worker, for unawareness of the

reporting obligation, for the incorrect characterization of cases, or for the fear of legal implications. Finally, the incompleteness/loss of information observed in this study, even after comparing three data sources, is still a challenge to overcome, so that more quality data are available.¹¹

The information systems will become more reliable as long as their limitations are diagnosed and overcome.¹¹ In this study, the inclusion of one more information source through the capture-recapture method was essential to recover underreported cases on the Mortality Information System – *SIM* –, besides showing important limitations of this system, such as the current impossibility of relating deaths due to aggression at work and the underreporting of residents deaths by the occurrence city.

The incentive and application of the capture-recapture method in health services that work with epidemiological data would allow to quantify underreporting of the available data sources, through registers overlap. In this study, as the focus was evaluating FOI, the underreport obtained would be more substantial if the commuting accidents were included, because they are probably more underreported. This is a suggestion for future and wider researches on the topic, as a last recommendation in this study.

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Authors' contributions

Bordoni PHC contributed to the study conception and design, and to the data analysis and interpretation.

Bordoni LS and Silva JM contributed to the data acquisition.

Drumond EF contributed to the study conception and design and data acquisition.

All the authors contributed to the study drafting, critical review of its intellectual content and final version approval, and declared to be responsible for all aspects of the work, ensuring its accuracy and integrity.

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