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Original Article

Relation between workplace accidents and the levels of carboxyhemoglobin in motorcycle taxi drivers

Luiz Almeida da Silva[1]
Maria Lúcia do Carmo Cruz Robazzi[2]
Fábio de Souza Terra[3]

Objective: to investigate the relation between workplace accidents and the levels of carboxyhemoglobin found in motorcycle taxi drivers. Method: correlational, quantitative study involving 111 workers and data obtained in July 2012 through a questionnaire to characterize the participants and blood collection to measure carboxyhemoglobin levels. Result: 28.8% had suffered workplace accidents; 27.6% had fractured the lower limbs and significant symptoms of carbon monoxide exposure were verified in smokers. The carboxyhemoglobin levels were higher among smokers and victims of workplace accidents. Conclusion: motorcycle taxi drivers had increased levels of carboxyhemoglobin, possibly due to the exposure to carbon monoxide; these levels are also increased among smokers and victims of workplace accidents. The study provides advances in the knowledge about occupational health and environmental science, and also shows that carboxyhemoglobin can be an indicator of exposure to environmental pollutants for those working outdoors, which can be related to workplace accidents.

Descriptors: Occupational Health; Accidents, Occupational; Environmental Pollution; Air Pollution; Workers.

[1] PhD, Adjunct Professor, Universidade Federal de Goiás, Jataí, GO, Brazil. Scholarship holder from Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).
[2] PhD, Full Professor, Escola de Enfermagem de Ribeirão Preto, Universidade de São Paulo, WHO Collaborating Centre for Nursing Research Development, Ribeirão Preto, SP, Brazil.
[3] PhD, Adjunct Professor, Escola de Enfermagem, Universidade Federal de Alfenas, MG, Brasil.

Corresponding Author:
Luiz Almeida da Silva
Universidade Federal de Goiás
Rodovia BR 364, km 193
Cidade Universitária
CEP: 75801-615, Jataí, GO, Brasil
E-mail: enferluiz@yahoo.com.br

Introduction

Air pollution has been a widely discussed subject as, with the technological advances and high number of motor vehicles in the cities, this factor becomes inevitable. Health diseases resulting from pollution affect several systems and the most commonly affected are the respiratory and the cardiovascular systems, which are closely linked and interdependent on gas exchange[1].

Workers who perform outdoor activities are exposed to high/low temperatures, wind, pollution caused by exposure to carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO_x) as nitrogen dioxide (NO_2) and nitric oxide (NO). Those who smoke are more susceptible to illnesses and accidents because they have more chances of having health issues, given the harmful substances resulting from the smoke produced by cigarette burning, such as CO[2-3].

Air pollution can occur through the emission of pollutants originated in various industrial processes, plantation burnings and combustion of motor vehicles, which generate CO. This gas is one of the most toxic and directly affects the respiratory system. About 80 to 90% of this element, when absorbed, is linked to the iron atom of the heme fraction of the hemoglobin (Hb) present in erythrocytes, forming the complex carboxyhemoglobin (COHb); the symptoms caused by this link are directly related to the increase of its levels[4]. Relatively low levels of COHb concentration in the blood may cause anomalies in the central nervous system[5]. In the United States, exposure to CO is generalized. For the population living in the cities, smoking is a major source of CO, as well as the exhaust of motor vehicles, work sources, household heating and cooking equipment[6].

Motorcycle taxi drivers figure among the workers who perform outdoor activities and they are a working group in a recent occupation in Brazil.

Formal workplaces have significantly decreased; in 2002, the country recorded the fourth position in the world ranking concerning unemployment rates, being only behind India, Indonesia and Russia[7]. New employment options were sought by workers, including motorcycle taxi jobs, as occurred in Thailand, Bogota, Bangkok[8], Cameroon[9] and Angola[10]. Workers in this occupation use a motorcycle as a working tool and their employment is usually informal.

The number of motorcycles circulating around the country has grown 246% in the last decade, reaching 18.5 million units; there has been an increase of 65.3% in the number of cars, reaching 37.2 million vehicles[11]. Motorcycle taxis offer advantages, such as speed and reduced prices, as well as disadvantages, such as lack of comfort, risk of accidents and emission of pollutants[11]. Motorcycle taxi drivers are directly exposed to pollution, which can cause health issues, besides the risks resulting from the work itself, like workplace accidents (WA), the risk of psychological disorders and fear of being robbed while transporting unknown people[12].

Over the past 15 years, mortality rates resulting from motorcycle accidents in Brazil has increased 846.5%, while car accidents have grown 58.7%[11]; this means of transportation is fragile and workers are exposed to the weather and WA[12]. The health problems they may have, specifically due to CO exposure, are: headaches, visual blurriness, dizziness, irritability, reduction of visual perception, fatigue, tachycardia, insomnia, hypertension, chest pains, dyslalia, faintness, hyporeflexia, respiratory disorders, irritation in the eyes, nose and throat and nausea. The contact with CO, which has an affinity with hemoglobin 240 to 300 times higher than with oxygen (O_2), leads to the formation of COHb, which competes with O_2 and reduces its levels in the blood stream, causing symptoms that may result in WA[3-4]. This finding about the occurrence of accidents and the contact with CO is illustrated by the investigations below.

In Serbia, a study about the effects of the increase in CO concentration in the air inside cars on the health conditions of exposed drivers and the occurrence of traffic accidents showed that the drivers from the exposed group had headaches, irritability, dizziness and palpitation more often than those from the control group. They also showed longer reaction time to sound and visual stimulation when compared to those who were not exposed; those who were exposed caused more traffic accidents than those from the control group[13].

In Poland, a worker in a coal mine was involved in a fatal accident; during the autopsy, blood from the heart cavity was collected and the analysis showed 20% of COHb. The exposure to CO results in inappropriate response to danger; this exposure sometimes does not cause fatal intoxication, but it can lead to an accident resulting in death; in the above mentioned case, there is a high chance that the CO was the cause of the fatal accident suffered by the worker[5].

In Russia, expert assessments of air accidents, particularly after exposure to CO and violation of professional duties, should consider that in some cases, the operators may have made mistakes that caused the aggravation of the accidents and, consequently, the death of the crew and passengers of airplanes[14].

Air pollution can lead to concentrations of COHb in non-smokers, similar to those found in smokers. Exposure to CO may prevent accurate estimates of time intervals, as well as the performance of more complex psychomotor tasks. The part of CO in motor vehicle accidents can be verified through data showing higher levels of COHb in drivers involved in accidents than in policemen and other people exposed as a result of their occupation[6].

Motorcycle taxi driver has become another informal occupation in Brazil. However, the work environment surrounded by environmental pollution with high levels of carbon monoxide emission, in conjunction with smoking and traffic-related risks, makes this new employment category subject to high risks of workplace accidents.

This study is justified by the lack of research about the triad levels of COHb, WA and motorcycle taxi drivers. Therefore, the present study was guided by the question: what are the levels of carboxyhemoglobin found in motorcycle taxi drivers in the city of Uberlandia, Minas Gerais state, and is there any relation between these levels and the occurrence of WA concerning these workers?

Based on the above, this study was aimed at investigating the relation between WA and the levels of carboxyhemoglobin found in motorcycle taxi drivers.

Method

Sectional, correlational study with a quantitative approach, involving a sample of 11 motorcycle taxi drivers in the city of Uberlandia, Minas Gerais state (MG).

The sample was calculated using the following equation:

$$n = \frac{N.p.q[Z_{\alpha/2}]^2}{p.q.[Z_{\alpha/2}]^2 + (n-1).E^2}$$

where n is the sample size to be used, p and q are the approximate possibilities of the two. $Z_{\alpha/2}$ is the normal distribution coefficient and, for such, tabulated values will be used, with an equation reliability of 95% or 0.95. "N" is the total size of the population used and "E" is the margin of error of 5% or 0.05[15].

The selection criteria used were as follows: to have been working as a motorcycle taxi driver for at least one year, regardless of gender; to be working without having taken sick leave for the last two months; not having any prior heart, respiratory conditions or anemia; to have worked since the beginning of the week and a minimum of eight hours on the day the interview and blood collection would take place.

Data collection took place in July 2012; a questionnaire to characterize the workers and record of symptoms related to their exposure to CO were used; it was developed by the authors based on research about the subject[2-4,16]. The instrument was submitted to a refining process undertaken by seven judges, occupational health and environmental health experts. Subsequently, 8 milliliters of venous blood was collected to measure the levels of COHb. The method used was the analysis of whole blood, free of clot by visible absorption spectrophotometry, co-oximetry, Roche® Cobas b221 analyzer (*in house* method)[17].

The reference value (RV) adopted in the scientific literature and in a previous research carried out in MG was considered, which also showed a value of up to 2.5% for non-smokers and not occupationally exposed. As RV for smokers, the level of 4 to 5% was established for those who smoke 20 to 40 cigarettes a day and of 8 to 9% for those who smoke more than 40 cigarettes a day[18]. With the purpose of standardizing the presentation of the results, the levels of COHb were classified as acceptable and not acceptable, considering the non-smoker motorcycle taxi driver with RV of 2.5%, the smoker of 1 to 2 packs of cigarette a day with RV from 4 to 5% and the smokers of more than 2 packs a day with RV from 8 to 9% as acceptable[17-18].

The study received approval from the Research Ethics Committee with registration number 1360/2011.

For the statistical analysis, the data were inserted into an *Excel* spreadsheet, double entered and analyzed with the software *Statistical Package for Social Science* (SPSS), version 17.0. For data analysis, the χ^2 test, the χ^2 exact test (when more than 20% of the cells in the contingency table show an expected value below 5) were used for the categorical or categorized variables. For the numerical variables, the nonparametric Mann-Whitney test was used. In relation to all the variables mentioned, the *odds ratio* – OR was estimated, including the use of logistic regression analysis with respective confidence intervals (CI) of 95%, considering a significance level of 5%, that is, the data were statistically significant for $p<0.05\%$[15].

Results

Levels of carboxyhemoglobin and symptoms of exposure to carbon monoxide

Table 1 presents the data related to the classification of COHb of each participant, considering the smoking habit.

Table 1 - Distribution of carboxyhemoglobin levels classified as acceptable and not acceptable among smoking and non-smoking motorcycle taxi drivers. Uberlandia, MG, Brazil, 2012 (n=111)

Carboxyhemoglobin classification (COHb)	Smoker				Total	
	No		Yes			
	N	%	N	%	N	%
Acceptable	78	70.2	15	13.5	93	83.7
Not Acceptable	8	7.3	10	9.0	18	16.3
Total	86	77.5	25	22.5	111	100.0

χ^2 Test (p<0.001)

Of the 86 non-smoking workers, eight (7.3%) showed unacceptable levels of COHb and, among the 25 smokers, 10 (9%) were also classified as not acceptable with p<0.001, with a statistically significant difference, as the percentage of not acceptable was significantly higher in the smoking group, with OR=6.50 and CI 95% (2.20-19.17). Therefore, those who smoke have 6.5 times more chances of having unacceptable levels of carboxyhemoglobin.

Table 2 shows the quantity of characteristic symptoms of CO exposure.

Table 2 - Quantity of symptoms reported by smoking and non-smoking motorcycle taxi drivers related to the exposure to carbon monoxide. Uberlandia, MG, Brazil, 2012 (n=111)

Quantity of symptoms	Non-smoker		Smoker	
	N	%	N	%
None	23	26.7	4	16.0
1	14	16.3	0	0.0
2 to 3	33	38.4	6	24.0
4 to 5	11	12.8	11	44.0
>5	5	5.8	4	16.0
Total	86	100.0	25	100.0

χ^2 Exact Test (p=0.001)

There was a significant occurrence of one symptom among non-smoking workers; whereas the percentage of smokers is significantly higher (44%>12.8%) in relation to 4-5 symptoms, thus showing their higher presence (p=0.001).

The 86 non-smokers reported 179 symptoms, with predominance of eye, nose and throat irritation (19.5%), irritability (11.7%), fatigue (10.6%), headache (10%), with an average 2.08 symptoms per motorcycle taxi driver. The 25 smokers reported 98 symptoms, predominantly irritability (15.3%), fatigue (14.3%), headache, eye, nose and throat irritation (10.2% each), with an average of 3.92 symptoms per worker. Although the occurrence of symptoms has multiple causes, they are more frequent in workers with high levels of COHb, being significant for headache, irritability, reduction of visual perception, fatigue, hyporeflexion (p<0.05).

Occurrence of workplace accidents

The occurrence of WA and their characteristics among motorcycle taxi drivers, including the period of the day and the weather conditions at the time of the accident, are shown in Table 3.

Table 3 - Distribution of workplace accidents among motorcycle taxi drivers, according to the characteristics of the accident, period of the day and weather conditions. Uberlandia, MG, Brazil, 2012

Variável	n	%
Workplace accident (n=111)		
Yes	32	28,8
No	79	71,2
Number* (n=32)		
1	31	96,9
3	1	3,1
Previous hours worked* (n=32)		
1-5	3	9,4
6-10	16	50,0
11-15	10	31,2
>15	3	9,4
Type of Workplace accident* (n=32)		
Collision	19	59,4
Fall	12	37,5
Run-over	1	3,1
Type of injury† (n=29)		
Excoriation	17	58,6
Closed fracture	8	27,6
Contusion	4	13,8
Period of day and weather conditions at the time of the accident* (n=32)		
Day	19	59,4
Night	8	25,0
Rain	4	12,5
Overcast	1	3,1

* only for accident victims
† only for injury victims

The description of the COHb levels among the workers, as well as the score of the test of association between these variables, is shown in Table 4.

In comparison with the numerical COHb, the motorcycle taxi drivers who suffered WA maintain a high average, as well as median and standard deviation. There is a significant difference, since those who suffered WA had significantly higher COHb percentages than those who did not suffer WA (p=0.02).

In the logistic regression analyses, the variables were not significant.

Table 4 - Analysis of the carboxyhemoglobin levels and their relation to workplace accidents among 111 motorcycle taxi drivers. Uberlandia, MG, Brazil, 2012

Workplace Accident	% Carboxyhemoglobin (COHb)					
	N	Average	Standard deviation	Median	Minimum	Maximum
No	79	3.0633	2.16506	2.3000	1.90	14.20
Yes	32	3.5188	2.93548	2.4500	2.10	18.00
Total	111	3.1946	2.40733	2.3000	1.90	18.00

Mann-Withney test: Z=2.28 (p = 0.02)

Discussion

The COHb levels evaluated among motorcycle taxi drivers showed that there was a statistically significant predominance of smokers (p<0.001) who showed not acceptable levels, being 6.5 times more likely to belong to this group. Cigarettes contain about 4,700 substances; in the combustion of tobacco, these substances are released, including nicotine, CO, tar, amongst others[19]. Given this, smokers have higher COHb levels, with double exposure to CO, both through smoking and air pollution. Cigarette smoking has become a public health issue[20] and, in relation to motorcycle taxi drivers, it increases the level of exposure to CO, as well as the occurrence of symptoms related to intoxication.

The workers' symptoms resulting from the exposure to CO were statistically significant in relation to smokers, showing a predominance of four to five symptoms reported by each participant, because the smoking habit is one of the main agents for increasing COHb concentration in the blood, amongst other symptoms.

A study undertaken in a university hospital in southern Brazil showed that 278 (18.9%) staff members reported the occurrence of diseases associated with smoking, being more frequent in the group of ex-smokers (p=0.008). The main diseases the participants reported were: circulatory, 124 (8.4%), respiratory, 99 (6.7%), psychiatric, 17 (1.1%) and gastrointestinal, 17 (1.1%)[21].

Given that this research is a cross-sectional study, a relative risk calculation (RR) among WA and COHb levels has not been performed, and it was not possible to infer higher exposure and risk of being involved in a WA. The results indicated that 50% of the motorcycle taxi drivers who suffered WA had higher levels of COHb (median=2.45; p=0.02).

In India, a study aimed at understanding the effects of air pollution on health showed that the short-term health effects reported by cooks resulting from exposure to CO were dizziness, headache, nausea, weakness, amongst others. In addition to these symptoms, there were evidences of health disorders, such as low birth weight, prenatal mortality, asthma, median otitis, cancer, nasopharyngeal tuberculosis, cataracts, blindness and cardiovascular diseases[22].

Traffic accidents involving motorcyclists have become frequent and contributed to the occurrence of sequelae and deaths. In Fortaleza (CE), a research sought to understand the risk of accidents workers who use motorcycles are exposed to, and one of the characteristics found is work by production, without fixed remuneration, besides traffic risks like accidents and robberies, amongst others. The workers increase the speed of their vehicles to raise their income and ensure their livelihood and, as a result, they are more exposed to WA[23]. In Maringá (PR), the most frequent type of accident among motorcyclists was collision with motor vehicles or vans, followed by falls; the predominant impact was transversal and side crashes, besides back collision with falls[17]. The accidents with these subjects are mostly serious and Personal Protective Equipment (PPE) needs to be used in order to minimize injuries.

In this study, most workers had accidents after having worked between six and ten hours before the accident, during the day with sunlight, suffered collisions, falls and had closed fractures due to the WA.

In Cali, Colombia, most deaths caused by motorcycle accidents were due to brain injuries related to the lack of helmet use. Next ranked chest and abdominal injuries, those affecting the lower and upper limbs, spinal cord injuries, traumatic damage to blood vessels, sprains and strains, which are also added to the most serious accidents because they entail death risk and may lead to sequelae and leave from work, sometimes for an indefinite period of time[24].

In Vietnam, there were 11,243 deaths resulting from traffic accidents in 2008 and, from these, 60% involved motorcyclists and passengers. In 2007, legislation made the use of helmets compulsory; later, 20 urban and rural hospitals reported that the risk rate of brain injuries and deaths caused by traffic accidents dropped by 16% and 18%, respectively, showing that continuous monitoring is necessary for the proper use of motorcycles and safety equipment[25].

Chile has a large number of motor vehicle and traffic accidents, involving 6.5% of the motorcycles in 2004; there was a high rate of accidents, with serious aspects that left sequelae, showing the difficulties in the adherence to established safety rules[26]. In Santa Fé, Argentina, the level of drivers' adherence to the traffic laws in relation to the use of safety equipment was investigated; concerning motorcyclists, only 12% used helmets and 6.7% carried children[27].

In Mar del Plata, also in Argentina, 451 motorcyclists were researched about the use of helmets; only 40% used it, 11% had the equipment but did not use and its use was more frequent among women. Although the use of helmets is compulsory, there is no appropriate police monitoring, which requires the government to adopt control strategies[28].

In a study carried out in Uberaba-MG, Brazil, with trauma victims, it was noted that motorcycle accidents were predominant. All patients suffered multiple traumas due to accidents: motorcycle collision (6), bicycle (2) or other vehicle (1) and fall (2). The traumas mainly damaged the following areas: skull (8), extremities (6), chest (4), face (4) and abdomen (3)[29].

In the association between the levels of COHb and WA, this was statistically significant (p=0.02). Workers who suffered WA in the period studied had higher levels than those who were not involved in accidents, with medians close to the adopted RV (2.5%). In Valencia, Venezuela, it was found that workers exposed to an environment close to places of intense traffic had higher levels of COHb and, consequently, more symptoms related to this exposure when compared to the control group, with predominance of fatigue, eye irritation, nausea, nasal irritation and sleepiness[30].

In this study, the levels of COHb were high and, as a result, related symptoms appeared, with the smokers being more exposed to the occurrence of these symptoms and chances of WA.

Motorcycle taxi is a recent type of work, and there has been little investigation about it. The investigation contributed to the advance of knowledge in the area of occupational health, since it identified that studies associating the levels of carboxyhemoglobin among motorcycle taxi drivers and the occurrence of WA are rare. The study provides advances in the knowledge related to occupational health and environmental science and suggests that carboxyhemoglobin can be an indicator of exposure to environmental pollutants for those who work outdoors. The limiting factor was the lack of comparison of the data obtained with another group of workers without exposure to pollution and without the occurrence of WA. It can also be highlighted that, even with the high OR of 6.5, the range of the CI was wide (2.20-19.17), which leads to the inference that the OR may be overestimated due to the study design.

Conclusions

Concerning the 111 motorcycle taxi drivers, 28.8% were victims of accidents; 27.6% had closed fractures, mainly affecting the lower limbs. The symptoms caused by exposure to carbon monoxide, such as irritability, reduction of visual perception and fatigue, were significant among smokers. The average level of carboxyhemoglobin in non-smokers corresponded to 2.3% and in smokers 5.7%. In relation to workplace accidents, the numerical carboxyhemoglobin showed a positive association with workplace accidents. Although the levels of pollution in the environment have not been assessed, it is known that the traffic in big cities favors the excessive presence of this pollution, putting the motorcycle taxi drivers studied at risk of becoming ill as a result of carbon monoxide intoxication, which increases the levels of carboxyhemoglobin and causes symptoms that may contribute to the occurrence of workplace accidents.

Based on this lack of literature about exposure to carbon monoxide and carboxyhemoglobin levels in motorcycle taxi drivers, it is recommended that further studies address this subject in order to expand the field of knowledge and the need to control the environment in the cities, with the purpose of protecting the population and workers.

In addition, proposals should be developed, involving governmental entities, associations and unions so that, in municipal regulations of the motorcycle taxi occupation, the need to include occupational health professionals be considered and, consequently, the need for the joint construction of Environmental Risk Prevention Program and Occupational Health Medical Program.

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