

IMPACT OF ENVIRONMENTAL POLLUTION ON CARBOXYHEMOGLOBIN LEVELS AMONG SMOKING AND NON- SMOKING MOTORCYCLE TAXI DRIVERS

IMPACTO DA POLUIÇÃO AMBIENTAL NO NÍVEL DE CARBOXIHEMOGLOBINA ENTRE MOTOTAXISTAS TABAGISTAS E NÃO TABAGISTAS

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ABSTRACT: Studies related to environmental pollution, carbon monoxide levels and smoking need to be deepened, especially in the case of traffic workers. Therefore, the objective was to verify the association between environmental carbon monoxide and carboxyhemoglobin levels among smoking and non-smoking motorcycle taxi drivers. A longitudinal epidemiological study was carried out with 95 motorcycle taxi drivers with measurement of the environmental carbon monoxide, carboxyhemoglobin in the exhaled air in three moments with interval of six months, between June 2014 and March 2015, as well as sociodemographic and occupational characteristics of these workers. The seasons of the year presented different carbon monoxide averages ($p < 0.05$), with higher levels in the spring and lower in the autumn, while carboxyhemoglobin levels among smokers and non-smokers were high in the winter, fair in the spring and low in the autumn. Statistical differences were observed between subgroups: between autumn and spring for non-smokers ($p = 0.024$) and between winter and autumn for smokers ($p = 0.042$). There was a positive correlation between carbon monoxide and carboxyhemoglobin levels for non-smokers ($r_s = 0.9983$; $p < 0.01$). Environmental pollution represented different levels in the four seasons of the year and significant association with carboxyhemoglobin levels. The carboxyhemoglobin levels were higher among smokers, with statistical significance between winter and fall seasons, while non-smokers presented normal levels, what confirms the direct influence of tobacco in carboxyhemoglobin levels.

KEYWORDS: Environmental pollution. Smoking habit. Occupational Health. Carboxyhemoglobin.

INTRODUCTION

Health and environment studies began in industrialized countries in the 1960s, when the Rome Club Report was published proposing to slow down the growth of industrial processes and other polluting activities (OLIVEIRA, 2012; SENECHAL et. al., 2015).

The presence of substances in the atmosphere resulting from human activities such as biomass fires and the use of petroleum-based automotive vehicles has been implicated in the genesis of environmental pollution, the latter being the main culprits (DRUMM et. al., 2014).

Personal habits are also factors that contribute to increased exposure to CO, particularly smoking, by inhaling high CO content at the moment of tobacco combustion. CO has a high

affinity with hemoglobin, forming the carboxyhemoglobin complex (COHb) responsible for the transport of oxygen. Elevated levels of COHb may cause decreased perception and visual acuity, dizziness, headache, nausea, vomiting, acute myocardial infarction, and, at high concentrations, death by asphyxiation (CANÇADO et. al., 2006; SALDIVA, 2010; BLEEKER, 2015; BARROS et. al., 2012; MENDES et. al., 2010; SILVA; ROBAZZI; TERRA, 2013).

In terms of the health of those that work in a traffic related environment, many of whom are exposed to the elements shaped by pollution, agglomeration of vehicles, heat, dust, all of which make it necessary for the researchers to pay special attention, in that they can better understand how these environmental conditions may affect the welfare of workers and the level of risk they face, as

well as for the passengers that they transport (SILVA; ROBAZZI; TERRA, 2013).

In this perspective, the present study seeks to evaluate the impact of environmental pollution on the level of carboxyhemoglobin among cigarette smoking and non-smoking motorcycle taxi drivers.

MATERIAL AND METHODS

Quantitative, epidemiological and longitudinal study carried out with motorcycle taxi drivers of the city of Jataí, Goiás, Brazil, located in southwest Goiás, with a population of 93.759 inhabitants. This population-based study included the 152 motorcycle taxi drivers affiliated to the motorcycle taxi drivers union (SIMOTAX) of this city (JATAÍ, 2007).

The motorcycle taxi drivers were approached in their workplaces and data collection was performed at the end of the day. They received

the necessary information about the study, from the reading of the Informed Consent form, and they were informed that the research would be carried out in three stages: the first one in June, the second in December 2014 and the third in May 2015. In these three collection moments, COHb levels in the exhaled air would be measured. A sociodemographic questionnaire was filled in the first collection.

The criteria for selecting drivers were: to work for at least six months in this profession, not having detected cardiovascular or respiratory disease or anemia self-reported. Those who, for any reason, did not participate in the second and third stages of the study were excluded.

Ninety-seven out of the 152 motorcycle taxi drivers met the selection criteria and started the study; in the second stage, there were two losses, remaining 95 participants, which represented 62.5% of the total population (152).

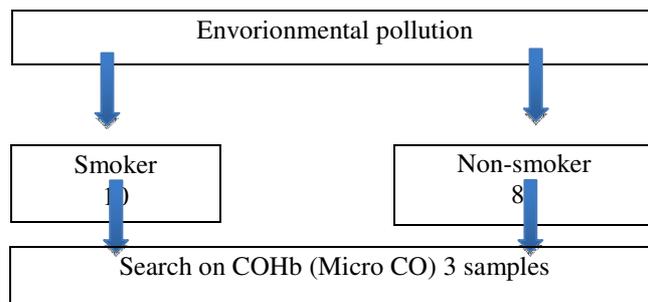


Figure I. Sample and stages of the study

A Micro CO Meter produced by Micro Medical Ltd., Rochester, UK, Gold Standard and previously calibrated was used for COHb measurements. This device is able to measure the concentration of exhaled carbon monoxide (COex) and COHb by means of an electrochemical sensor, having the following technical properties: resolution of 1ppm (parts per million), immediate demonstration of the levels in ppm and percentage of COHb with carbon monoxide measurement at a concentration of 0-500 ppm, operating range 0 to 40° at atmospheric pressure (TAMUSSINO&CIA, 2013).

The standard that regulates biological monitoring in Brazil recommends the use of COHb as a bioindicator of CO exposure, with a reference value of up to 1% of blood concentration and the Maximum Allowed Biological Index of 3.5%, whose values coincide with those proposed by American Conference of Governmental Industrial Hygienists (ACGIH, 1999).

Data collection followed the sequence: in the first stage, motorcycle taxi drivers were approached in their work places at the end of the afternoon and invited to complete the sociodemographic questionnaire. In order to measure COHb, the participants remained in seated position, asked to inhale, pause for 20 seconds and then slowly and completely exhale the air in the mouthpiece of the device (TAMUSSINO; CIA, 2013). In the second collection, in December 2014, only COHb levels were measured, in the evening, following the previously established parameters. In the third collection, in May of 2015, a new measurement of COHb was performed. In the case of smokers, having smoked a cigarette within the last 30 minutes was adopted as criterion at all stages.

At the same time, the environment was monitored by measuring CO in the air in four strategic points of the city with records throughout 12 months, for four hours a day every 30 seconds, two consecutive weeks at the beginning of each

season; the following measurements were carried out one day per week until the start of the next season. Measurements were coincident with the period of collection of data from motorcycle taxi

drivers, using a PorTable Digital CO Meter Minipa - MCO-100, with values in ppm.

The distribution of CO levels and location of motorcycle taxi points are shown in Figure 2.

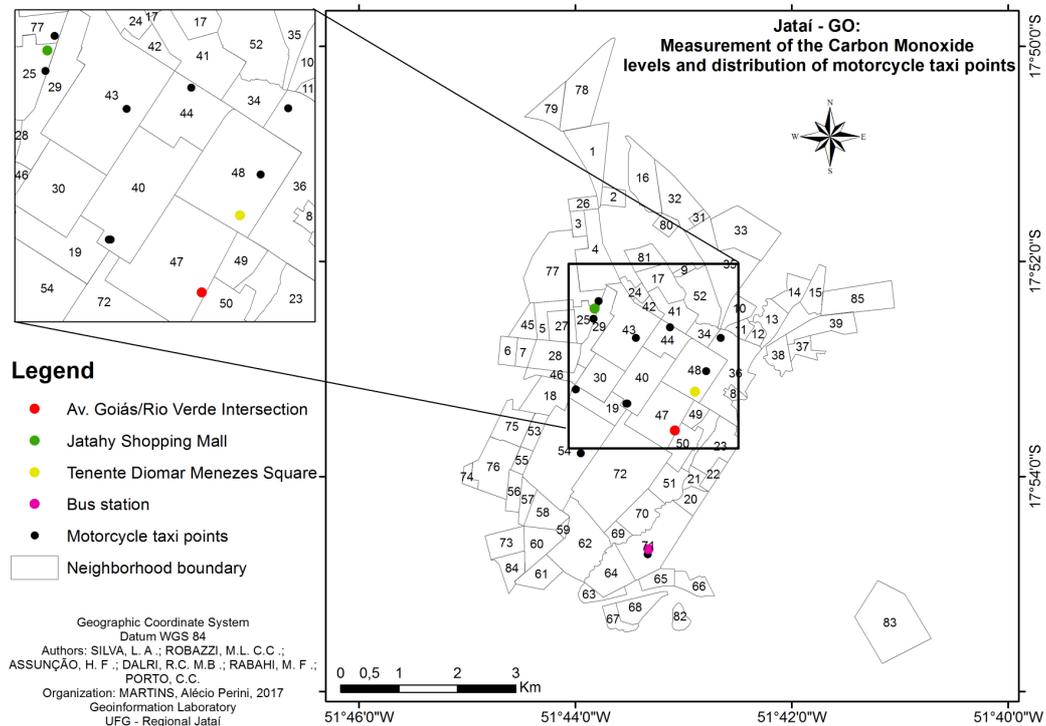


Figure 2. Map of the distribution of monitoring points and motorcycle taxi points. Jataí, Goiás, Brazil, 2015.

Primary and secondary standards set by the National Environmental Council (CONAMA) for CO emission are: average concentrations of up to 9 ppm of CO every 8 hours and average concentration of 35 ppm every one hour (BRASIL, 1990).

The data obtained was double-entered in an electronic *Excelspreadsheet* and analyzed in the *Statistical Package for Social Sciences* (SPSS) for Windows, version 22.0 and STATA, version 12.0. Initially, a descriptive analysis of variables related to baseline characteristics was performed. Quantitative variables were presented as means and standard deviation (SD) and qualitative variables as absolute and relative frequencies.

The *Kolmogorov-Smirnov* test with *Lilliefors* correction was used to test normality of quantitative variables.

The following statistical analyses were performed: *Spearman* correlation between environmental CO levels in winter, spring, summer and autumn, as well as between CO and COHb environmental levels; *Friedman* test to evaluate differences in COHb concentration levels during the three periods, which were investigated for each group, separating smokers and non-smokers. In the

case of statistical significance, *Post hoc* tests for multiple comparisons between winter, spring and autumn were used. The *Mann-Whitney test* was used to assess differences in COHb concentrations between smokers and non-smokers in each season. The association between environmental CO and COHb was tested considering CO as the predictor variable.

In all tests, p values <0.05 were considered statistically significant.

The study was approved by the Research Ethics Committee of the Federal University of Goiás, under Opinion 609.327.

RESULTS

Among the 95 motorcycle drivers analyzed, 98.9% were males, 68.4% had primary education, 66.7% were black or brown; 50.5% had partners, 89.5% were non-smokers and 67.4% had already suffered occupational accidents. The mean age and monthly income were 39.09 ± 8.71 years and $2439.35 \pm 1,428.34$ Brazilian Reals, respectively (Table 1).

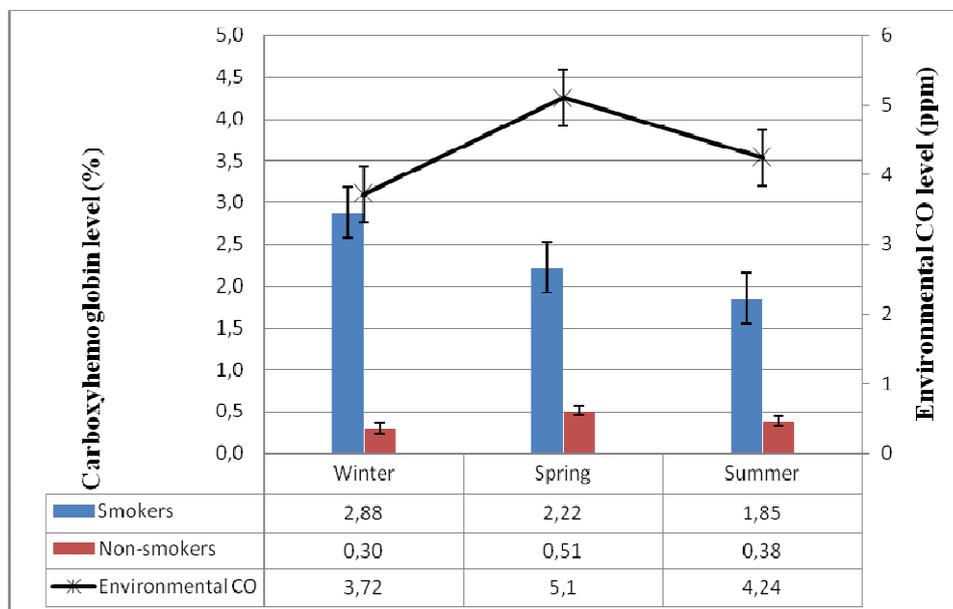
Table 1. Personal and occupational characteristics of motorcycle taxi drivers. Jataí, Goiás, Brazil, 2015.

Variables	Mean or n	SD or %
Age (years)	39.09	8.71
Monthly income (Brazilian Reals)	2.439.35	1.428.34
Marital status		
Without partner	47	49.5
With partner	48	50.5
Skin color		
White	32	33.7
Black/brown	63	66.3
Schooling		
Primary education	65	68.4
Secondary education	30	31.6
Smoker		
Yes	10	10.5
No	85	89.5
Number of cigarettes/day *		
≤ 20	7	70.0
>20	3	30.0
Occupational Accident		
Yes	64	67.4
No	31	32.6

* Only for smokers

The pollution levels obtained by monitoring the environmental CO during the 12-month period, according to the seasons, are shown in Figure 3. The highest CO average (5.1 [SD] ± 4.24 ppm) was

observed in the spring, followed by the summer, with similar levels (4.98 [SD] ± 4.40). Winter presented the lowest rate of environmental CO (3.71 [SD] ± 3.80).

**Figure 3.** Environmental carbon monoxide concentration and carboxyhemoglobin levels among smokers and non-smokers. Jataí, Goiás, Brazil, 2015.

Concerning COHb levels among smokers and non-smokers, high levels were observed among smokers in the winter, with intermediate values in the spring and low values in the autumn. In the case of non-smokers, there were no significant

differences between seasons, although the spring average was slightly higher. The *Friedman* test indicated a statistical difference between subgroups, in autumn and spring, for non-smokers ($p = 0.024$). On the other hand, statistical difference between

COHb levels in winter and autumn were seen among smokers ($p = 0.042$). Finally, the comparison of COHb levels between smokers and non-smokers was statistically different only in the winter ($p < 0.001$) (Figure 3).

Whereas the environmental CO showed an increasing tendency in the spring, intermediate values were observed in the winter and summer, with decrease in the autumn. With the objective of

evidencing relations between CO levels in the seasons, the *Spearman* correlation analysis showed significant relations ($p < 0.001$) for all pair-wise comparisons, i.e. between winter and summer (-0.020, $p < 0.01$), winter and autumn (-0.173), winter and spring (-0.078), autumn and spring (0.287), autumn and summer (0.136), and spring and summer (0.015) (Table 2).

Table 2. Correlation coefficient between different seasons of the year. Jataí, Goiás, Brazil, 2015.

Season	Winter	Fall	Primavera	Summer
Winter	1.000	-	-	-
Fall	-0.173*	1.000	-	-
Primavera	-0.078*	0.287*	1.000	-
Summer	-0.020**	0.136*	0.015	1.000

Spearman Correlation (r_s); * $p < 0.001$; ** $p < 0.01$.

Regarding the relationship between environmental CO levels and COHb levels in motorcycle taxi drivers, there was a significantly perfect positive correlation among non-smokers ($r_s = 0.998$; $P < 0.01$). On the other hand, smokers had a negative but non-significant correlation (-0.500; $p > 0.05$).

In the simple linear regression analysis, using smokers as reference, we observed an association between environmental CO and COHb levels among non-smokers (β : 0.988; 95% CI: 0.24; 1.55, $p = 0.03$), with $R^2 = 0.996$.

DISCUSSION

The environmental CO concentration in the studied city (Jataí, Goiás, Brazil) was acceptable within the values recommended by CONAMA 03/90, not exceeding the averages, with significant differences between seasons and higher concentration in the spring, and lower in the autumn.

The city surveyed has an annual average temperature that oscillates around 22.2°C, with maximum averages of 24.4°C and minimum averages of 18.2°C. It presents a rainy period extending from October to April and a dry period corresponding to the months of June through August. The relative humidity of the air varies from 49 to 80% and, in the summer, it is highest in the hottest months of the year. In the spring, there is a transition from the rainy to the dry period, with intensification of vehicular traffic. In the fall, the green arborization makes the climate to become milder (BARROS; GUILHERME; CARVALHO, 2010).

Air pollution effects on human health are variable. It must be emphasized, however, that even when contaminants are within acceptable standards, other factors may contribute to the emergence of harmful effects such as temperature increases or oscillations, thermal inversions, wind regime, soil occupation with vertical constructions that prevent dispersion of pollutants, including CO (SETTE; RIBEIRO, 2011; JARDIM, 2011).

Although the averages recorded are within the standards suggested by CONAMA, which considers a concentration of up to 9 ppm for a period of 8 hours as acceptable, as recommended by environmental agencies of the United States, California and the European Union, the recommendations of the Environmental Company Of the State of São Paulo (CETESB) says that values above 4.5 ppm make air quality regular. For the present study, values during winter and autumn only were found to be within the range considered as good quality air, that is, 3.72 and 4.24 ppm, respectively (BRASIL, 1990; CETESB, 2007; IEMA, 2012).

The exponential growth of the population and the number of vehicles in the cities, as well as vertical constructions, causes the emission of polluting gases to increase and to keep in suspension for longer times, due to the difficulty to disperse. Thus, cities with highest population densities have a greater tendency to concentrate such effects, affecting the health of people in general, regardless the type of work (RADICCHI, 2012).

A study conducted with traffic police officers working in South India aimed at measuring COHb levels after exposure for three hours compared to office workers at a teaching hospital in

the same region. Among participants, 76.5% of the traffic police officers had COHb > 2.5%, while no office clerk reached that level; furthermore, 41.2% of police officers had COHb levels > 4% ($p < 0.05$) (NAIR et. al., 2017).

As it is well established, tobacco use in any form alone causes increased CO exposure. When associated with environmental pollution, the level of COHb is even more increased among smokers, which exposes them to greater risk (DÓREA; BOTELHO, 2004).

In the present study, COHb levels among non-smokers were within the normal parameters in the three measurements, while these were elevated in the smokers. In the first measurement, they were 9 times higher; in the second, 4.39 times; and in the third, 4.74 times, with significant differences between overall means of smokers and non-smokers in the winter season. This fact shows that smoking causes COHb levels to remain altered, and workers are more likely to develop grievances related to environmental pollutant exposure, in addition to specific alterations in the respiratory system caused by substances present in tobacco (MAGA et. al., 2017).

The Brazilian Society of Pneumology and Tisiology recommends the value of 6 ppm as an acceptable COex cutoff point. When applied to the conversion formula of the device used to measure and convert COex to COHb, where this value is multiplied by 0.16, a COHb value of 0.96% would be obtained. This is close to that recommended by the Ministry of Labor, which is 1% for non-smoking and not occupationally exposed people (TAMUSSINO & CIA, 2013; REIS, 2008; SBPT, 2008). In the case of smokers, acceptable levels established in the literature are 4 to 5% for smokers who smoke between 20 and 40 cigarettes/day (NOLASCO, 2010).

A clinical trial conducted in Alabama with 673 volunteers aiming to identify the best cut-off point for COex upon cessation of smoking showed that the established levels were 3 to 4 ppm (0.48 - 0.64 of COHb). It is also suggested that such limits need to be analyzed with caution, given the peculiarities of each population, as well as the levels of environmental pollution where they live (CROPSEY et. al., 2014).

A study carried out in Cuiabá, Mato Grosso, Brazil, with non-smokers who practiced physical exercise showed a COex mean of 2.69 ± 0.88 ppm and COHb of 0.43 ± 0.14 , regardless sex and the practice of smoking ($p > 0.05$) (SALICIO et. al., 2016). This finding agrees with that of the present study on the behavior of COHb levels, considering

that non-smoking motorcycle taxi drivers presented the highest mean of $0.51 \pm 0.81\%$.

In order to identify COex levels among smokers and non-smokers in places with different pollution levels, a study conducted in three Polish cities, Warsaw, Krakow and Kozenice showed that living in cities with less than 100,000 inhabitants was a protective factor for smokers and non-smokers when compared to populations living in cities with 100,000 or more inhabitants. The average COex level, based on the cut-off point of 4ppm, was significantly higher among smokers than among non-smokers ($p < 0.0001$), and it was higher among non-smokers in large cities than non-smokers in small cities ($p < 0.0001$). The mean level of exhaled CO was also found to be higher in active smokers in big cities than in small cities, but without statistical significance ($p = 0.14$) (MAGA et. al., 2017).

These data allow us to infer that in the city studied (Jataí, Goiás, Brazil), a municipality with less than 100 thousand inhabitants and environmental CO levels within the recommended parameters, non-smokers had COHb values within the recommended, whereas smoking participants, the work represented a factor that increases COHb levels in this category.

A study carried out with 100 university students from the health area in Várzea Grande and the University of Cuiabá - MT showed that the average COHb found among smokers was $4.6 \pm 2.4\%$, (95% CI: 2.95 - 6.15), among former smokers was $2.3 \pm 1.1\%$, (95% CI: 1.41-3.18), among passive smokers, $2.3 \pm 1.2\%$ (95% CI: 1.65 - 2.94) and among non-smokers, $1.3 \pm 1.2\%$, (95% CI: 1.05-1.65) (BARROS et. al., 2012). The results of the present study are divergent in relation to the cited study, both for smokers and non-smokers. Increased COHb levels, despite pre-established patterns, present different values when measured at different locations, as influenced by the production and dispersion of CO levels.

As for the association between COHb levels and environmental CO values in the four seasons of the year, a significant correlation was observed only among non-smokers. The lack of significance among smokers may be due to the small number of participants, lack of control of the amount of cigarettes smoked per day, as well as the route travelled by the motorcycle taxi drivers. As the environmental quality is close to the recommended parameters, it can be assumed that levels that are already increased among motorcycle taxi drivers may have masked the interference of environmental CO in the formation of a greater amount of COHb, a factor that tends to be overcome when it comes to

larger cities, with higher levels of pollution (MAGA et al., 2017).

A study conducted in the city of Uberlândia, Minas Gerais, Brazil, with 111 participants verified the association between work-related accidents and COHb levels among motorcycle taxi drivers showed that those who had suffered accidents presented significantly higher average COHb ($3.51\% \pm 2.93$) ($p = 0.020$) (SILVA; ROBAZZI; TERRA, 2013). This allows us to infer that environmental exposure to carbon monoxide, along with increased COHb levels, add to the various factors contributing for the occurrence of traffic accidents, placing traffic workers at constant risk.

Limitations

The limitations of the present study are the small number of smokers, the lack of control of the amount of cigarettes smoked per day, and the absence of fixed stations to monitor pollutants.

The absence of measures of COHb levels in the spring season, which was not performed due to logistic difficulties, also represents a limitation.

Authors' contributions

LAS participated in the conception of the study, design, data collection, analysis, interpretation and writing. MLCCR e RCMBD participated in the analysis, interpretation and critical review. HFA participated in data analysis, environmental assessment, critical review. LGM, SES, GSM participated in data collection, analysis and critical review. MFR participated in the critical review, writing. CCP conception of the study, design, analysis, interpretation and writing. All authors approved the final version of the article

CONCLUSIONS

COHb levels were higher among smokers, with statistical significance between the seasons of winter and fall, whereas the levels found among non-smokers were normal.

Environmental pollution by CO showed variation throughout the four seasons of the year and only among non-smoking motorcycle taxi drivers. There was a significant association with COHb levels, although still within normality parameters established by national and international environmental agencies.

RESUMO: Os estudos relacionados à poluição ambiental, níveis de monóxido de carbono e o tabagismo, necessitam de aprofundamento, com destaque para os trabalhadores do trânsito. Para tanto, verificar associação entre níveis de monóxido de carbono ambiental e carboxihemoglobina em mototaxistas tabagistas e não tabagistas. Estudo epidemiológico, longitudinal, realizado com 95 mototaxistas com mensuração do monóxido de carbono ambiental, carboxihemoglobina no ar exalado em três momentos com intervalo de seis meses, entre junho de 2014 e março de 2015, assim como as características sociodemográficas e ocupacionais desses trabalhadores. As estações do ano apresentaram diferentes médias de monóxido de carbono ($p < 0,05$), com níveis maiores na primavera e menores no outono, enquanto os níveis de carboxihemoglobina entre tabagistas e não tabagistas apresentaram-se elevados no inverno, intermediário na primavera e baixos no outono. Observou-se diferença estatística entre subgrupos, no outono e na primavera para os não tabagistas ($p = 0,024$) e entre o inverno e outono para os tabagistas ($p = 0,042$). Houve correlação positiva entre os níveis de monóxido de carbono e carboxihemoglobina para não fumantes ($r_s = 0,9983$; $p < 0,01$). A poluição ambiental representou diferentes níveis nas quatro estações do ano e associação significativa com os níveis de carboxihemoglobina. Os níveis de carboxihemoglobina mostraram-se mais elevados nos tabagistas, com significância estatística entre a estação inverno e a do outono, enquanto os não tabagistas apresentaram níveis normais, o que reforça a participação direta do tabaco nos níveis de carboxihemoglobina.

PALAVRAS CHAVE: Poluição Ambiental. Hábito de fumar. Saúde do Trabalhador. Carboxihemoglobina.

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