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Effects Of Environmental Factors And Atmospheric Pollution in the Incidence of Hospital Admissions of Patients With Stroke In São Paulo City By Stroke In São Paulo City

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Abstract

Introduction: Stroke is one of the major causes of morbidity and mortality worldwide, difficult to treat and recover. The risk of developing stroke may be associated with environmental factors. Objective: To analyze the association between ambient temperature, air humidity and atmospheric pollution with the incidence of hospital admissions for stroke in the city of São Paulo in 2016. **Methods**: This is an ecological study, carried out by secondary

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data collection in the city of São Paulo in 2016. The definition of Stroke was according to the tenth revision of the International Classification of Diseases in codes: I60, I61, I63 and I64. Results: There was a positive correlation between the incidence of hospital admissions for stroke and in SO_2 in air (rho: 0.80, p=0002) in women. In men there was a positive correlation between the number of hospital admission and SO_2 concentration (rho: 0.570, p=0.005). Conclusion: We observed a positive correlation between the incidence of stroke and the concentration of the atmospheric pollutant SO_2, an important fact for the intervention in the dispersion of pollutants.

Keywords: Stroke; Hospital Admission Service; Atmospheric Pollution.

Introduction

Stroke is one of the major causes of worldwide deaths, difficult to treat and recover from patients (Huang et al., 2017). In more severe cases, this illness can lead to physical and mental disabilities, which damages the lifestyle of many individuals (Thayabaranathan et al., 2017).

Besides, stroke damage may continue even during treatment, because of the encephalic white matter degeneration (Sampaio-Baptista et al., 2018). This creates an obstacle for rehabilitation, which can be an important factor for people in financial difficulties, on account of its high costs or even labor problems (Ganesh et al., 2017).

In this context, the study of some environmental factors, which leads to an increase of stroke incidence, is important because the treatment and prevention of this morbidity are more effective in a risk control scenario (Stambler et al., 2016). Moreover, the treatment methods of stroke are precarious in many Brazilian areas, fluctuating a lot even in the same town (Rolim et al., 2011).

Environmental factors have a great impact on population health, being that air pollution was associated with at least 5.708.000 deaths all over the world in 2015 (Forouzanfar et al., 2015). These characteristics surround all the individuals and affect the type of work produced by each person daily, so the quality of life is closely related to the ambient air pollution (Cohen et al., 2017).

The atmospheric pollution, temperature and air humidity, already have been associated with risk of stroke (Bai et al., 2018; Qian et al., 2013; Requia et al., 2018). This became more evident in developing countries, due to the expressive changes in the environmental components, because in these regions, the environmental components, most like the air pollution, changes constantly. This can corroborate the increase in cases of stroke in those regions (Chen et al., 2013). Therefore, despite the fact that stroke incidence has been falling in Southeastern part of Brazil in the

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period from 2008 to 2012 (Adami et al., 2016), the numbers of death by this disease is increasing due to population rises and epidemiology transition in the country (Vincens et al., 2015).

Thus, the increasing accumulation of atmospheric pollutants and changes in temperature conditions significantly influence the number of deaths , which negatively impacts public health in Brazil. However, the influence of environmental factors (pollution, temperature, and humidity) on hospital admission rates due to stroke within the Brazilian population is still insufficiently studied , which may hamper the prevention and treatment of this morbidity in the national territory.

The city of São Paulo is considered a global metropolis, with the largest population concentration in Brazil and with a vast industrial park according to the Brazilian Institute of Geography and Statistics (IBGE). Therefore, the air pollution and climate changes influence the residing population in São Paulo, due to the accumulation of pollutants in this place by vehicular traffic and industrial gasses emitted in the region (Pestana et al., 2017).

Stroke, as already seen, has high rates of mortality and high incidence worldwide (Mozaffarian et al., 2016) as it is observed in Brazil . Other studies have already considered the relationship of this disease with pollution and temperature (Amancio et al., 2012). However, in 2016, the city of São Paulo experienced high pollutant rates in addition to very high or very cold temperatures for national standards. This has raised doubts about how these environmental variables can affect the incidence of hospital admissions for stroke in a large global metropolis.

Thus, the main objective of this article is to analyze the association between ambient temperature, air humidity and atmospheric pollution with the incidence of hospital admissions for Stroke in the city of São Paulo, Brazil, in 2016.

Methods

Study design

This is an observational, ecological study that uses secondary data referring to hospital admissions for Stroke and environmental conditions of São Paulo city, Brazil, in 2016.

Study location and period

This study was carried out at the Epidemiology and Data Analysis Laboratory of the Department of Public Health at the Faculty of Medicine, ABC (FMABC) in 2016.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Study population and eligibility criteria

The study was conducted with individuals living in the capital of São Paulo, the city with the largest population accumulation in the country, with 11,376,685 people, of which 5,386,957 are men and 5,989,728 are women, according to the Census of Brazilian Institute of Geography and Statistics (*DEMOGRÁFICO ICIBGE, 2010).*

Data collection

The definition of stroke is in accordance with the tenth revision of the International Classification of Diseases (ICD10) codes: I60, I61, I63, and I64, which correspond to intracranial hemorrhage, cerebral infarction, stroke not specified as hemorrhagic or ischemic in the list morbidity of ICD-10. The number of hospital admissions in the city of São Paulo was obtained by the Hospital Information System of the Unified Health System (SIH / SUS), which are available in DATASUS.

Hospital admissions for stroke are included in the database of the Brazilian Ministry of Health, available on the website of the Department of Information Technology of SUS (DATASUS), which is the official database of public health data in Brazil and is available for free access to the user at http://datasus.saude.gov.br/.

We stratified the data on hospitalization for stroke by age and sex of the individuals, aged between 15 and 80 years or more, stratified every 5 years. The incidence of hospital admissions of the SUS was obtained by dividing the number of monthly hospital admissions for stroke in the total resident population of the city of São Paulo in the year 2016.

The Environmental Company of São Paulo State (CETESB) is the agency of the state of São Paulo responsible for the control and monitoring of environmental conditions in the region. Created on July 24, 1968, by Decree No. 50,079. Data of this company will be used to analyze the temperature of the environment, the humidity of the air and the concentration of particulate material and pollutant gases in the place and period studied. This data is available in the site http://www.cetesb.sp.gov.br/.

The temperature, humidity, and concentration of pollutants were expressed by the monthly average of each variable during the year 2016, and the data on SO2, particulate matter (MP10), and minor particulate matter (MP 2.5) were expressed in μg/ m3, and the CO concentration was expressed in ppm.

CETESB has several stations for data collection in São Paulo. The stations D. Pedro II, Pinheiros, Interlagos, Marg. Tietê-Pte and Pico do Jaraguá. They have collected air humidity data referring to Parque D. Pedro II, Pinheiros, Ibirapuera, Interlagos, Marg. Tietê-Pte and Pico do Jaraguá. Data for sulfur dioxide were collected from D. Pedro II Park, Congonhas, Cerqueira

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César, Interlagos and Marg. Tietê-Pte. The concentration of carbon monoxide was obtained from Santo Amaro, Parque D. Pedro II, Congonhas, Ibirapuera, Mooca, Cerqueira César, Grajaú-Parelheiros, Pinheiros and Marg. Tietê-Pte. For MP10 data were obtained from Santana, Santo Amaro, D. Pedro II Park, Congonhas, Mooca, Cerqueira César, N. Senhora do Ó, Grajaú-Parelheiros, Interlagos, Itaim Paulista and Marg. Tietê-Pte. Finally, MP2.5 was collected at the stations: Parque D. Pedro II, Congonhas, Ibirapuera, Cid. University-USP, Grajaú-Parelheiros, Itaim Paulista, Marg. Tietê-Pte and Pico do Jaraguá.

We analyzed each marker (ambient temperature, air humidity, MP10, MP2.5, SO_2, and CO) unitarily in all seasons, in order to study the association between stroke and the presence of all markers.

Before the beginning of the collection, training was carried out to level the research in the databases. The collection team has three (3) researchers, two independent researchers and a third researcher to identify possible discrepancies in the collected values.

Data Analysis

For the descriptive analysis of the quantitative variables, as they had a normal distribution (Shapiro-Wilk test, $p>0.05$), mean, standard deviation, minimum and maximum were used.

To analyze the association between exposure to pollutants and the incidence of hospital admissions for stroke, the Pearson and Spearman correlation test will be used. The confidence level adopted will be 95% and the statistical program used will be the Data Analysis and Statistical Software for Professionals (Stata) version 13.0®.

Ethical and legal aspects of the research

As we based this study on secondary data, since it is not able to identify the individual and the data is free and unrestricted on the Internet, there is no need for this project to be sent to the Research Ethics Committee for its appreciation, as expressed in the resolution 466/2012.

Results

The study observed an average in the year 2016 for CO of 0.58 ppm (SD=0.12), not exceeding 0.81 ppm. For MP10, there was an annual average of 28, 26 μg / m3 (SD=7.13), ranging from 20, 45 μg/m3 to 42.81 μg/m3. MP2.5 had a mean of 2016 of 13.40 μg/ m3 (SD=5.01). SO_2 had an annual average of 1,90 μg/m3 (SD=0,90), with a minimum of 1,20 μg/ m3 and a maximum of 4,20 μg/ m3. The mean of the year 2016 for the ambient temperature was 16, 18°C (SD = 3.95). Relative humidity had a mean of 55.62% (SD=7.83). The minimum humidity was 40% and the maximum humidity was 65.17%. The incidence of hospital admissions in

females averaged 6.38 (SD=1.22), ranging from 3.03 to 7.69 admissions. Among men, this mean was 7.61 (SD=1.47), with a minimum of 3.48 and a maximum of 8.92 hospitalizations (Table 1).

A positive correlation between the pollutants and the incidence of hospital admissions for total stroke in women, CO (rho: 0.22, p=0.480), MP10 (rho: 0.52, p=0.080), SO_2 (rho: 0.80, p=0.002), and MP 2.5 (rho: 0.51, p=0.090). For the male, the study also observed a positive correlation between these variables, CO (rho=0.09, p=0.780), MP10 (rho: 0.27, p=0.390), SO_2 (rho: 0.570, p=0.005) and MP 2.5 (rho: 0.24, p=0.440). Where "p" means the level of significance of the study and "rho" means the strength of association using the analytical model of the study

This study observed that the higher incidence values of stroke were stated in the colder and drier months of the year between May and August notably referring to the female stroke incidence of 769 in August and the male incidence of 8.92 in July . This fact matches with high concentrations of the pollutants, mostly SO_2 that had the most relevant value of 4.2 μg/ m3 in July (Figure 1).

There was a negative correlation between temperature and the incidence of total stroke in women and men. In the case of relative air humidity, there was a positive correlation with the incidence of total stroke for men, however, this correlation is negative for women. It is also observed that only correlations involving SO_2 were statistically significant (Table 2).

Discussion

We carried out the current study in the city of São Paulo, a large, heavily industrialized state region. In this study, the main findings were the higher rate of hospital admissions for stroke in males compared to females, in addition to the positive correlation found between the concentration of SO2 and the incidence of stroke.

One study analyzed mortality from stroke in the large Brazilian metropolises, including São Paulo, and found that mortality in men due to this morbidity is higher when compared to women (Pinheiro, 2014; Soares, 2010). This may be related to the higher incidence of male hospital admissions found in the present study, as the samples in both cases are similar.

In addition, a review proposed by Piassaroli et al. has already described the higher rate of hospital admissions in men compared to women, who used a total of 92 articles on the subject related to stroke, and most of these articles proves a similar scenario, with a higher incidence in men (Piassaroli et al., 2012). Furthermore, in an ecological study similar to this, Alcantara et al., found out that the incidence of stroke in men is 19% higher than in women (Alcantara et al., 2017). Thus, the present study

follows the same proportion, with the incidence in men being 7.61 and in women being 6.38, which shows that our results corroborate a tendency regarding sex.

The positive correlation between the SO2 concentration and the incidence of hospital admissions for stroke in both sexes may be justified by the absorption of this gas in the membranes of the respiratory tract, which may contribute to the activation of neuronal signals that stimulate bronchial constriction and cardiovascular, as already explained by Tunnicliffe, in a study on the effects of SO2 in adults, where he found that this gas participates in neural mechanisms (Tunnicliffe et al, 2001).

In this scenario,, it is possible to note that the increase of SO2, generates an increase in hospital admissions for stroke in São Paulo, which are more present in the colder months of the year, periods in which the SO2 rates reach the highest averages. This increase in SO2 in these months can be understood as a consequence of the thermal inversion, which occurs in the coldest time of the year, reducing the dispersion of pollutants (Amancio et al, 2012).

The study positively correlated other pollutants with the incidence of stroke. However, no other pollutant in question had a statistically significant result ($p>0.05$). Huang et al. stated in their study that it is not possible to accurately correlate stroke with particulate matter, which supports our result, since this correlation can vary even in the same year in different seasons (Huang et al, 2017). In the case of carbon monoxide, the statistically insignificant result may be influenced by a protective role that this gas promotes in low concentrations against ischemic stroke, as already explained by Wang et al. in his study on the effects of CO as a neuro protector (Wang et al., 2011).

This poor association can be considered, on the other hand, a negative point of this study. This can be explained by analyzing each pollutant separately and in the short term, which can camouflage possible reactions between the organism and all pollutants together. In a review, for example, by Ljungman et al., it was possible to point out that in developed countries studies have already observed such correlation (Ljungman et al., 2014). In addition, Lipsett et al. stated that long-term exposure to particulate matter and fine particulate

material significantly increases the risk of stroke (Lipsett et al., 2011).

Conclusion

Stroke is, indeed, a morbidity that affects many individuals in the city of São Paulo. Stroke is, indeed, a morbidity that affects many individuals in the city of São Paulo. What impacts the most is the conjunction of the

difficulty of treatment, the extended periods of rehabilitation, and the life-lasting dependence of these patients, which significantly reduces the quality of life of this population.

The present study observed that there is a positive correlation between total hospital admissions for stroke and the concentration of atmospheric pollutant Sulfur Dioxide (SO_2). This fact must be considered in the preparation of public measures for the intervention in the dispersion of pollutants, so concentrated in the city of São Paulo.

Despite the limitations of a transversal study, it is important to create hypotheses, which can be further investigated and confirmed by other studies. This is one of the first studies to create hypotheses of this important theme, in the biggest metropolis of Brazil.

Limitations

The faint association of other pollutants, but SO_2, can be considered a negative point of this study. This can be explained by analyzing each pollutant separately and in a short period, which can camouflage possible reactions between the organism and all pollutants together. In a review by Ljungman et al., it was possible to point out that such correlation has already been studied in developed countries (Ljungman et al., 2014). In addition, Lipsett et al stated that long-term exposure to particulate matter and fine particulate material significantly increases the risk of stroke.

The decreased use of tobacco in the population may have interfered in the results of this study, since this study is aggregated and does not observe each individual separately, meanwhile other studies have observed the positive correlation between stroke and use of tobacco.

Abbreviations

1. ICD10: International Classification of Diseases
2. SIH / SUS: Hospital Information System of the Unified Health System
3. SD: Standard Deviation
4. CO: Carbon Monoxide
5. SO_2: Sulfur Dioxide
6. MP10: Particulate matter
7. MP2.5: Minor Particulate matter

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Conflicts of interest:

There was not any conflicts of interest

Table 1: Characterization of the sample.

Varibles	Average (SD)	Minimum - maximum
Carbon monoxide (CO)	0,58 (0,12)	0,44 - 0,81
Particulate Material (MP10)	28,26 (7,13)	20,45 - 42,81
Fine Particulate Material (MP2.5)	13,40 (5,01)	9,25 - 25,00
Sulfur Dioxide (SO2)	1,90 (0,90)	1,20 - 4,20
Temperature	16,18 (3,95)	9,42 - 22,88
Humidity	55,62 (7,83)	40,00 - 65,17
Incidence of total female hospital admissions	6,38 (1,22)	3,03 - 7,69
Incidence of total male hospital admissions	7,61 (1,47)	3,48 - 8,92

SD: Standard Deviation.

Source: Companhia Ambiental do Estado de São Paulo - CETESB (http://cetesb.sp.gov.br). Sistema de Informação Hospitalar (SIH / SUS). Dados disponibilizados pelo Departamento de Informática do Sistema Nacional de Saúde (DATASUS-www.datasus.gov.br). Ministério da Saúde, Brasil.

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Table 2: Correlation between pollutant gases, particulate matter, air temperature and humidity with total hospital admissions.

Varibles	Total female hospital admissions		Total male hospital admissions	
	rho	p*	rho	p*
Carbon monoxide (CO)	0,220	0,480	0,090	0,780
Particulate Material (MP10)	0,520	0,080	0,270	0,390
Fine Particulate Material (MP2,5)	0,510	0,090	0,240	0,440
Sulfur Dioxide (SO2)	0,800	**0,002**	0,570	**0,005**
Temperature	-0,450	0,140	-0,190	0,560
Humidity	-0,160	0,620	0,060	0,860

* Spearman's correlation test .

Source: Companhia Ambiental do Estado de São Paulo - CETESB (http://cetesb.sp.gov.br). Sistema de Informação Hospitalar (SIH / SUS). Dados disponibilizados pelo Departamento de Informática do Sistema Nacional de Saúde (DATASUS-www.datasus.gov.br). Ministério da Saúde, Brasil.

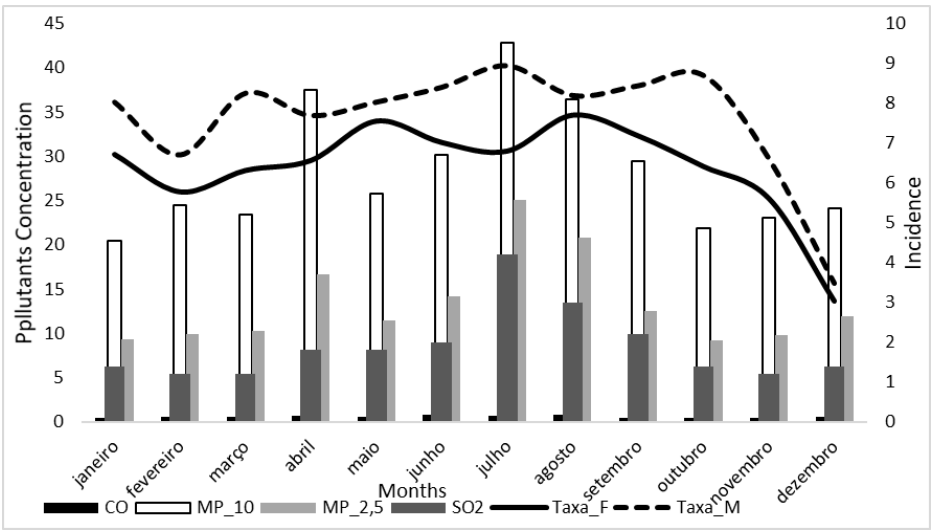

Figure 1: Graphic illustration of the atmospheric pollution variation by month and its correlation with the incidence of Stroke between a year.

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