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Original Article

Use of indicator as the basis to evaluate the exposure to PM_{10} air pollution and its significance in public health: case study-Rio de Janeiro, Brazil

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SUMMARY

Air pollution is an important public health concern because it can affect large populations, which, in most cases, does not have choices about the air they breathe. There are many sources of air pollution in both urban and non-urban areas. Environmental health indicators can be of particular importance to emphasize the greater vulnerability of certain populations, such as children or the elderly, and to account for it in public policies associated to health and the environment.

The article aims at improving information support for environmental health policies and at bringing valid and useful information on Rio de Janeiro about health impacts of environmental hazards for decision-makers. Based on these characteristics, a structure is proposed for the application and managing specific environmental health problems, identifying PM_{10} as an urban air pollution indicator.

Key-words: indicator, urban air, particulate matter, public health

RESUMEN

El uso de indicador como base de evaluación de exposición de polución aérea urbana a PM_{10} y su importancia para la salud pública: estudio de caso - Río de Janeiro, Brasil

La contaminación atmosférica es una preocupación importante de la salud pública porque puede afectar a poblaciones grandes, que, en la mayoría de los casos, no tiene opciones sobre el aire que respiran. Hay muchas fuentes de la contaminación atmosférica en áreas urbanas y no urbanas. Los indicadores ambientales de la salud pueden ser de importancia particular para subrayar la mayor vulnerabilidad de ciertas poblaciones, tales como niños o ancianos, y para explicarla en los órdenes públicos asociados a la salud y al ambiente.

El artículo tiene como objetivo mejorar la información para las políticas sanitarias ambientales y generar información válida y útil en Río de Janeiro sobre impactos en la salud causados por los peligros del medio ambiente. De acuerdo con estas características, se propone una estructura para el uso y manejo de los problemas de salud ambientales específicos, identificando PM_{10} como indicador de polución aérea urbana.

Palabras clave: indicador, aire urbano, materia particulada, salud pública.

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INTRODUCTION

The nature and magnitude of the association between particulate matter and human health effects has been increasingly recognized(1,2). Air pollution is associated with a variety of health effects including respiratory tract irritation, asthma, heart and lung diseases, decreased immunity, and increased risk of cancer. The very young and very old are particularly sensitive to air pollution (3-7).

The recent literature shows that short-term increases in morbidity and mortality following severe air pollution episodes are linked to high concentrations of particles. This is confirmed more recently even with lower concentrations in different countries and cities. Excess deaths, mainly due to respiratory and cardiovascular diseases, are closely associated with levels of particles. Particle exposure is associated with increased hospitalization for respiratory illnesses and with other aspects of respiratory morbidity (emergency room visits, respiratory symptoms severe enough to restrict activity, cough, acute changes in pulmonary function tests, asthma, and increased use of medications). Chronic respiratory health effects, such as chronic obstructive pulmonary disease, also increase with increases in PM_{10} (6-9).

Particulate matter (PM) arises from natural sources and processes, for example, soil and wind-blown dust, fires, and sea-salt aerosol. Other particles are by-products of various combustion or industrial processes. Still others enter the ambient air by condensation and other processes. Some particles are directly emitted, while others form in the atmosphere through gas-to-particle conversion reactions. Most healthy people recover from the effects of air pollution when air quality improves. However, people with existing lung and heart diseases (such as asthma or chronic obstructive pulmonary disease) are at risk of dying from either short-term or long-term exposure to air pollution (7-10).

PM in the atmosphere is comprised of a range of materials arising from a variety of sources. PM with an aerodynamic diameter of less than 10µm is known as PM_{10}. It is this size range of PM suspended in air that has been found to have adverse health effects. It is considered that PM_{10} may increase the obstruction of breathing passages and may also worsen existing lung disease. There is also a possibility that some particulates penetrate deep into the lung tissue and may be carcinogenic (9-11).

PM air pollution includes several types of particles with different chemical compositions. Smaller sized particles (less than 2.5 microns in diameter, $PM_{2.5}$) come from combustion sources, while large particles (between $PM_{2.5}$ and PM_{10}, i.e. particles between 2.5 and 10 microns in diameter). Epidemiological studies indicate that small particles or particulate matter air pollution is related with increases in mortality, especially in people older than 60 years old who have existing cardiopulmonary diseases and in infants (10,12). It is also associated with health problems including aggravation of asthma, especially in children, and other chronic lung diseases, impacts on lung function, and increased susceptibility to infectious illnesses.

PM_{10} particles (the fraction of particulates in air of very small size, <10µm aerodynamic diameter) can potentially pose significant health risks, as they are small enough to penetrate deep into the lungs. Larger particles are not readily inhaled. Consist of two fractions. The primary component consists of those particles emitted directly to the atmosphere from natural and anthropogenic sources, such as road traffic, industry or wind blown dust. The secondary component is formed in the atmosphere by chemical reactions of gases, particularly sulphur dioxide, nitrogen oxides and volatile organic compounds.

Concern about the potential health impacts of PM_{10} has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring the smaller particle fraction, $PM_{2.5}$, which is capable of penetrating deepest into the lungs, or to even smaller size fractions or total particle numbers (12,13). The impact of local primary and secondary sources is superimposed on a regional background. In 1987, the United States Environmental Protection Agency restricted the National Ambient Air Quality Standards to the mass concentration of inhalable particles of 10 µm aerodynamic diameter or less (PM_{10}), and this pattern is used in most countries. A 24-hour standard was set at 150 µg/m^3 and an annual 24-hour standard set at 50 µg/m^3 (13).

In recent years, urban pollution has emerged as the most severe problem, because of its harmful effects on health and deterioration in living conditions. To avoid further exacerbation, a thorough environmental policy is required based on scientific planning of pollution control. An appraisal of the existing pollution sources constitutes the first step of tackling the problem. A precise understanding of their location, temporal distribution, level of activity and their interconnection with the massive ow of pollutants in the atmosphere, comprise the most crucial elements in the overall formulation of a model, which can be used for quantitative predictions concerning real situations. The understanding of such concepts impels the development of structures, which, has proved to be extremely useful for sketching out urban ecosystem and management (Figure 1).

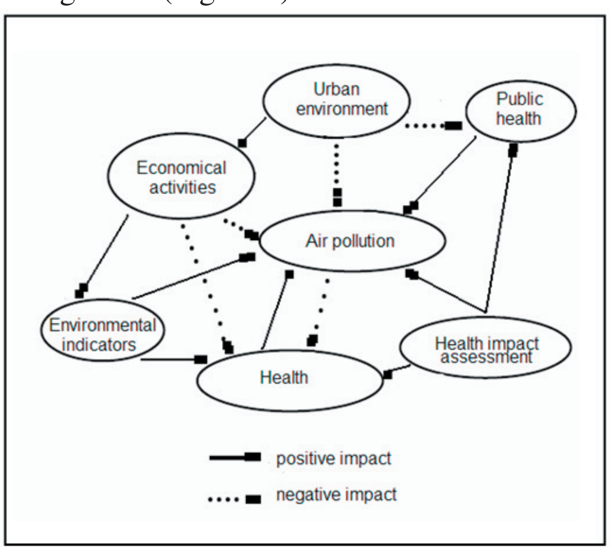

Figure 1. Schematic diagram of urban ecosystem and management

Indicators

Indicators have a specific denotation and a specific purpose so that they normally possess two distinct functions: i) they make easy analysis of the big picture through a rough and ready collection of information concerning a reduced number of measurements and parameters in a way that would not be possible for more detailed assessment of the exact situation; and ii) they aid in the statement of the results to the users and the general public by presenting normally complex situations in a concise and simplified way (14).

Indicators are essentially parameters, or values derived from such parameters, which provide information about a phenomenon, environment or area but whose significance goes beyond that directly associated with the parameter value. Also, since indicators are used for widely varying purposes, it is important that they be based on well-defined criteria. One such set of criteria is that established by the Organisation for Economic Co-operation and Development (OECD)(14,15), which include: i) policy relevance; ii) analytical soundness; and iii) measurability.

In the case of environmental health, relevant indicators are those representing well-established links between health and the environment. The indicators may not be based on cause-effect relationships. In fact, there are a few established cause-effects relationships related to the health effects of environmental exposure because of the lag time between exposure and health outcome and the difficulty in identifying the dose or timing of exposures which may have occurred many years earlier (16-18). As proposed by Corvalán et al. (19,20), an environmental health indicator may be defined as an expression of the link between the environment and human health, targeted at an issue of specific policy or management concern and presented in a form which facilitates interpretation for effective decision-making. Also, environmental health indicators can offer clear and succinct information on the state of the environment and its potential effects on human health. They correspond to a useful instrument to support policy, particularly environmental policies whose effects may only be detectable many years after their implementation due to their long time perspective.

In the last decade or so, the popularity of environmental indicators has also increased due to their applicability to other forms of environmental analysis (20-21). Although possibly the most attractive aspect of environmental indicators is their use in the assessment of performance, whether of a project, of industry or of a whole nation. However, some of these issues may be more or less important in individual regions or countries, and some important regional or national issues may be missing. Moreover, certain populations may be at greater risk to poor health, such as children, those living in poverty, etc. Where, when and how to intervene and how policies aimed at reducing environmental health risks should better re ect the vulnerability of these sub-populations is a key consideration and an important dimension of public policy related to health and the environment. An intervention in the early stages of life can have lifelong benefits for the society as a whole (Figure 2).

Sustainability indicators represent a useful tool that can be used to help communities develop in more sustainable directions. They have three central functions: i) to simplify the main concepts related to sustainable development; ii) to quantify and measure aspects of sustainable development;

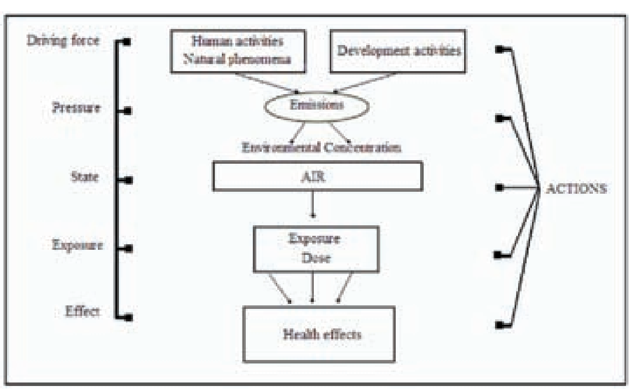

Figure 2. Health policy framework related to health and environment

and iii) to communicate them to the public and policy makers.

Through these central functions, sustainability indicators help policy makers and the public monitor progress in the country's sustainable development path, while inspiring people to take individual action and instigating change towards more sustainable directions. Just after the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, was consolidated a major weight to be laid on the use of environmental indicators in policy formulation and decision-making.

The construction of indicators and indices

For construction of indicators and indices is necessary be aware that them often have widely different requirements so that it is common for indicators to be tailor-made for specific needs and to be developed and organized around specific structures established for a specific purpose. These structures are not essentially governed by an exclusive set of criteria and they can also vary as newer information on the performance of the environment becomes available and society's values evolve.

In this context, it was developed the 'pressure-state-response' (PSR) structure (20). The PSR structure is based on a concept of causality: once the human activities apply pressures on the environment and change its quality and the quantity of natural resources. The public responds to these changes through environmental, general economic and sectoral policies. In a wider logic, these steps form part of an environmental cycle, which includes problem awareness, policy formulation, monitoring and policy assessment.

Structures are a methodology to express the associations between the causes and the impact on a system. In the environmental health context, structures are used to generate a link between health effects and ambient air pollutant concentrations. This methodology have been developed to highlight the level of specificity or required focus of a specific monitoring programme, and thus the adaptation of the structure is dictated by the goals and objectives of the monitoring exercise. Whether the interest of the monitoring programme is to look at the factors concerned in greater detail leading to the pressures on a system, at the states or responses within the system, or at actions aimed at reducing negative impacts is determined by the programme goals and its ultimate purpose.

Identifying vulnerable groups and individuals and achieving knowledge about the collective and individual risk perception and/or risk consciousness will form a basis for efficient action scheduling and taking. To this conclusion, structures have been planned to develop and obtain environmental and health indicators. The choice of a structure constitutes one of the most essential questions in developing environment and health indicators.

In that context, the Table 1 consolidates and expresses the core set of indicators established by the OECD including a number of air quality related indicators (14,15). These relate is direct to urban environmental quality. Slightly different indicators may be applicable in each case, although several of the indicators are related or have similar or equivalent data sources. All indicators are also classified on the basis of accessibility or the effortlessness of data compilation. Therefore, indicators are indicated as being either quantifiable in the short term (S), requiring additional empirical work and data collection effort and therefore only measurable in the medium-term (M) and those measurable in the long-term since they need significant data development work (L).

Impact of air pollution on mortality and morbidity

Epidemiological studies of the health impact of air pollution in general or selected air pollutants have a very similar methodology. In essence, the researchers would identify the level of air pollution in different geographical areas or in a specific geographical area over time and attempt to link it to an identified health outcome. Indicators for air pollution included the above air pollutants singly or in combination.

Important studies developed complex statistical analyses to deal with the daily variations of both exposure and outcome indicators and to adjust for other confounders, especially weather elements. Donaldson **et al**. (22) duplicated the same research protocol in Minneapolis-St. Paul, Minnesota. The findings were similar. Hospital admissions for pneumonia increased 17% (2-33%) for every 100 μg/m^3 increase in PM_{10} and 15% (0-36%) for every 50 ppb increase in ozone. Hospital admissions increased by 57% (20-106%) for an increase of 100 μg/m^3 of PM_{10} but was not associated with an increase in ozone level.

Boyce *et al*. (23) examined the association between PM_{10} and daily deaths of the residents of the Birmingham, Alabama, metropolitan area. A monotonic relation was detected between 24-hour average PM_{10} level and daily mortality with no evidence for a threshold down to concentration of 20 μg/m^3. In this context, the risk of dying increased by 11% (2-20%) for a 100 μg/m^3 increase in PM_{10}.

Brown *et al*. (24) examined the association between hospital emergency room visits for asthma and PM_{10} concentrations in eight hospitals in the Seattle metropolitan area. A strong trend was evident by quartiles of PM_{10} concentration. The risk for emergency asthma increased by 3.7% (1.2-6.4%) for a 10 μg/m^3 increase in PM_{10} (4-day average).

Mediavilla-Sahagún and ApSimon (25) reviewed studies up to that date to examine the association between particulate matter and mortality. They limited their review to properly designed and analyzed studies that adjusted for other pollutants and weather variables. It was reported a consistent finding across different studies linking particulate matter to mortality. The mean increase in mortality for an increase of 10 μg/m^3 in PM_{10} was reported as 0.96% with a range that varied between 0.31% and 1.49%. A dose-response relationship between PM_{10} concentration and mortality was noted.

Table 1. Pressure-state-response structure for air quality indicators assessment

	PRESSURE		STATE		RESPONSE	
Issues	Indicators of environmental pressures		Indicators of environmental conditions		Indicators of social responses	
Climate Change	• Index of greenhouse gas emissions* • CO_2 emissions	M	• Atmospheric concentrations of greenhouse gases* • Global mean temperature*	S S	• Energy efficiency • Energy intensity • Economic and fiscal instruments	M/L S M
Ozone Layer Depletion	• Index of apparent consumption of ozone depleting substances* • Apparent consumption of CFCs and halons	M S/M	• Atmospheric concentrations of ozone depleting substances* • Ground-level UV-B+ radiation*	S/M M	• CFC recovery rate*	M
Acidification	• Index of acidifying substances* • Emissions of NOx and SOx	M/L S	• Concentrations in acid precipitation	S	• % of car fleet equipped with catalytic converters* • Capacity of SOx and NOx abatement equipment of stationary sources*	S/M M/L
Urban Environmental Quality	• Urban air emissions: SOx, NOx, VOC* • Traffic density • -- urban • -- national	M/L M S	• Population exposure to: • --air pollution*	L M	• Economic, fiscal and regulatory instruments*	M
General indicators, not attributable to specific issues	• Road traffic volumes*	S			• Pollution control and abatement expenditures	S/M

Note: indicators marked with an (*) are "main" indicators

MATERIAL AND METHODS

We have focused on the development of methodology for the so-called 'issue' indicators. In order to facilitate "mapping" of policy questions over the indicator set, the issues must relate to aspects of environmental health which are both of relevance to the decision-makers and - directly or indirectly - amenable to control. A number of criteria and evaluations have been used to select the priority issues of environmental health concern. Structurally methodology used a spatiotemporal structure. This can be described as a progression which starting with non-spatial exploration of the health and environmental data such as temporal trends and frequency distributions for example (13-15).

For the PM_{10} data collection started during the first hour of the day and encompassed 24 hours from January/2001 to December/2004. Concentrations were determined in μg/m^3.

PM_{10} data were daily measured during the studied period at four stations (network) which are used in air monitoring at Rio de Janeiro. The correlation between the variables was estimated by the Pearson correlation coefficient. The program InstaT for Windows, version 3.036 [2006], Statistical Services Centre, University of Reading, United Kingdom, was used for data compilation and analysis.

For calculation of exposure to PM_{10} as prescribed by WHO (18), in the studied population was used the equation below. For that, it was calculated hospital admissions within total population under of 5 years old interned with respiratory problems and in the total population above 60 years, interned with respiratory problems also, the significance of these related internments with PM_{10}.

$$Ex_y = \sum_i (P_i / P) * (Cy_i - Rv_y)$$

$$Where \Rightarrow P = \sum_i (P_i)$$

Definition:
P = population
Pi = subpopulation
y = PM_{10}
Ex = Exposure
C = concentrations
RV = annual concentrations and reference values

Subsequently, for discussion, following the PSR structure, were combined methodologies in environmental epidemiology, human exposure assessment and other health and environment sciences to produce and analyse data, to convert these data into valuable and understandable information that can be interpreted and used by those responsible for environmental health protection. Its main tools are linkage methods of health and environment data, the use of environmental health indicators to quantify and monitor the local situation, and the interpretation and translation of resulting information into the decision-making process.

Area study

Air quality in Rio de Janeiro is generally most affected by local sources of air pollution. Air pollution monitoring is conducted in areas where there are known air pollution sources, usually based on regulatory requirements. A sampling process was conducted at the area study in which particulates levels were recorded over a prolonged period of time and at different atmospheric conditions. Sampling was conducted using a high-volume sampler that consists of a blower/motor unit and is designed for continuous 24 hours a day sampling.

Study period and source of data

Due to readiness of the data, as reference period for analyze them, were used the period from January/2001 to December/2004 containing hospital admissions, and morbidity by asthma. The data have information as sex, age, address, dates and causes of the morbidity codified in agreement with the international classification of the diseases, International Code of Diseases (ICD10-J00-J99).

Description of study site: Aerial Basin in Rio de Janeiro

The data of PM_{10} were obtained of the municipal network of environment. The monitoring stations are located in Copacabana, Centro, Tijuca and São Cristóvão (Figure 3).

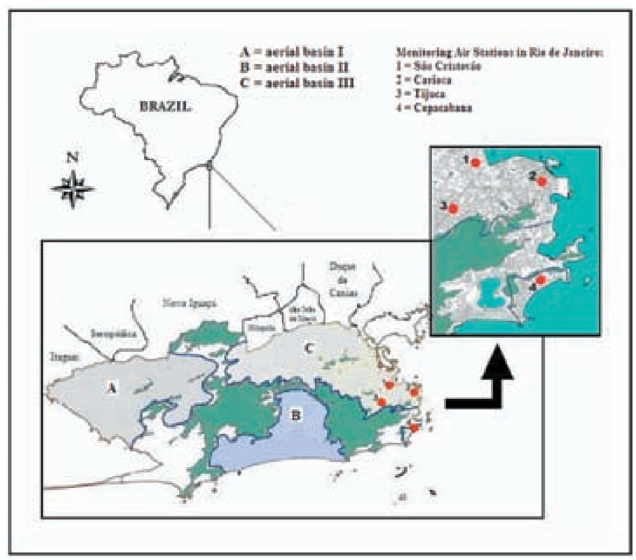

Figure 3. Monitoring air stations of study site

The climate is the type tropical, hot and humid, with local variations, due to the altitude differences, vegetation and proximity of the ocean, the medium temperature is of 22 °C, with high daily averages in the summer (30 to 32 °C); the rains vary from 1200 to 1800 mm annual. In the of May to September, due to performance systems of discharges pressures that they dominate the area happen frequently situations of atmospheric stagnation and high pollution indexes.

Within the existent metropolitan areas in Brazil, Rio de Janeiro is the one that it presents the largest demographic density, approximately 4955.92 hab/km^2 and 100% of urbanization degree. It is also the first largest population concentration, vehicles, industries, generating serious problems of pollution in the air.

On the other hand, Rio de Janeiro presents physical characteristics that improve problems related to the quality of the air, such as: altered topography, in uence of the sea and Guanabara Bay in the distribution and dispersion of pollutant, discharges temperatures that favour the formation of photochemical processes, besides the intense occupation of the soil.

RESULTS

Linking air pollution levels with morbidity and PM_{10} levels outcomes is one way to estimate the burden of disease from the air quality in a given area. We conclude an apparent relationship between PM10 measurements taken in Rio de Janeiro and respiratory symptoms. Such facts are evidenced in figures 4 and 5 showing in uence that PM_{10} levels had strongly in mortalities for respiratory problems such at under of 5 years as in above of 60 years.

On the other hand the admission tax for breathing symptoms in the age groups studied by PM10 is 38% minor for under of 5 years and 22% for above of 60 years. In similar study done in another area eat in case it controls without urban and industrial in uence the taxes of attacks and deaths are, on average, of the order of 62% smaller of deaths and internments in both age groups, corroborating, fundamentally, in the observations found in this article.

The relationship between young and elderly people indicate that using respiratory symptoms/ PM_{10} prescription rates as a proxy indicator is potentially important, mainly by unconsidered the socioeconomic and other determinants that drive the relationship of acquisition power rates. Hence, it might be more useful to use the prescription data indicator as a separate, additional indicator to obtain a more complete spectrum of related PM_{10} effects.

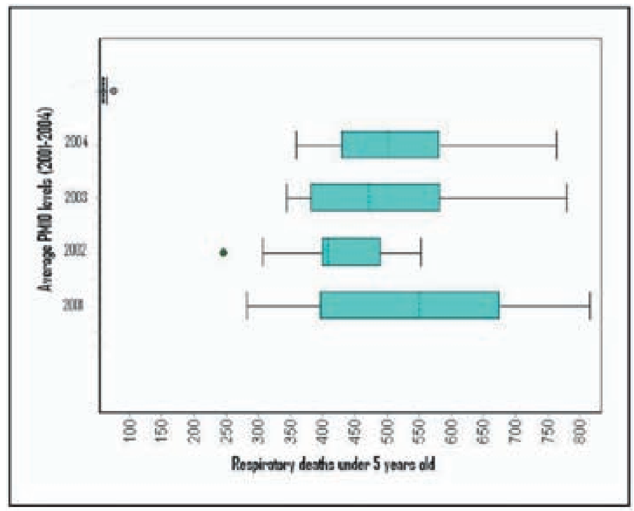

Figure 4. Respiratory deaths data occurred during period 2001-2004 (under 5 years old)

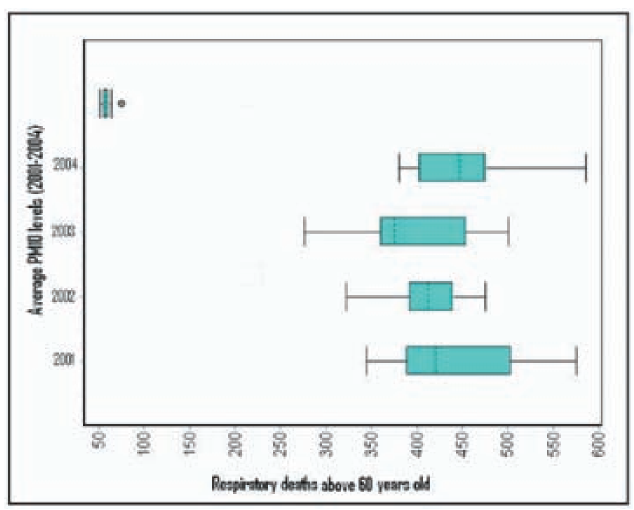

Figure 5. Respiratory deaths data occurred during period 2001-2004 (above 60 years old)

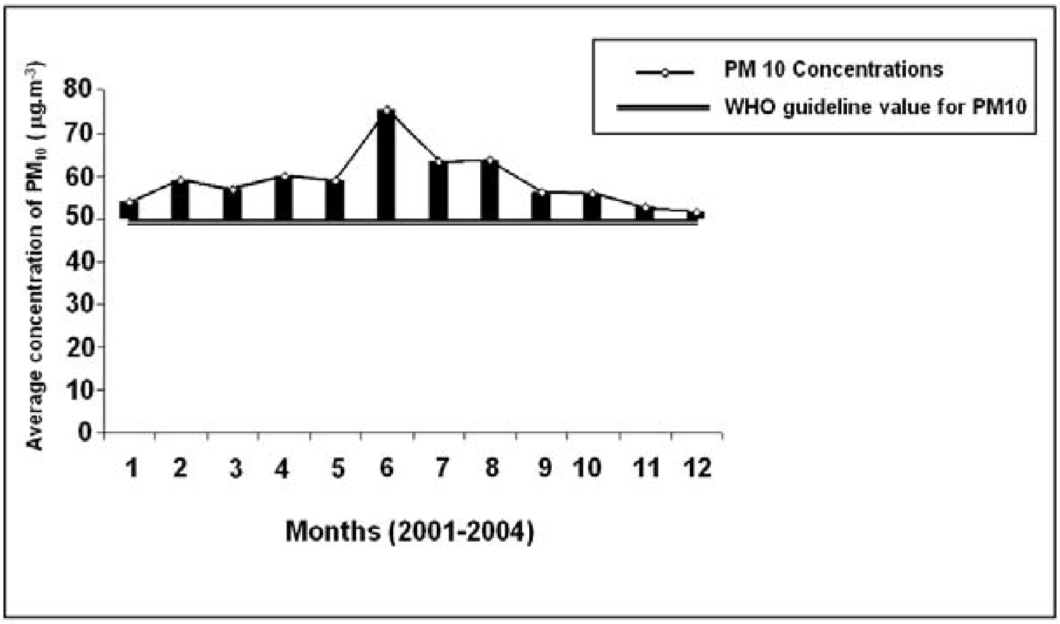

Figure 6. Average of PM_{10} emissions data (µg/m^3) during 2001-2004

Concentrations of particles in urban areas of Rio de Janeiro pose a major air quality concern. Regional monitoring programmes have increased and become more extensive since the 1990s and have shown that PM_{10} concentrations infringe, systematically, the air quality guideline values in many urban areas.

In relation the network monitoring, the Centre Station has higher PM_{10} concentrations than Copacabana, Tijuca and São Cristovão. For all period studied daily PM_{10} concentrations measured at these four sites showed results superior for levels of the PM_{10} concentrations exceeding 50 µg/m^3. The Figure 6 expresses PM_{10} data during 2001-2004.

DISCUSSION

There is an increasing need and demand for indicators, to help support and monitor policy on environment and health. As environmental effects occur on a long time horizon, we have be in mind that, consequently, as result, the effects of a public intervention will be detectable many years after undertaking actions.

The survey of the environmental health risks requires a better understanding of the relationship between environment and health (26,27). To calculate the state of environmental health, sets of indicators has to be developed to inform and help policy makers appreciate the success of current environment and health policies aiming at dropping adverse health effects, thus facilitating priorities setting.

In our observations the meant by adverse health effects of air pollution must range from nuisance and aesthetic disturbances to severe health outcomes such as premature mortality and disability. The cut-off point is not a straightforward or simple scientific decision; it is rather an arduous societal decision that addresses the social, economical, technological, and political price for the risk deemed accepted. The American Thoracic Society (ATS), for example, suggests guidelines for what constitutes an adverse respiratory health effect. ATS lists the following health outcomes in order of severity: i) increased mortality; ii) increased incidence of cancer; iii) increased frequency of symptomatic asthmatic attacks; iv) increased exacerbation of disease in persons with chronic cardiopulmonary or other diseases; v) reduction in forced expiratory volume at 1 second and forced vital capacity associated with clinical symptoms; vi) increased prevalence of wheezing in the chest; vii) increased prevalence or incidence of chest tightness; viii) increased prevalence or incidence of cough; ix) increased incidence of acute upper respiratory tract infections that interfere with normal activity; x) acute upper respiratory tract infections that do not interfere with normal activity; xi) eye, nose, and throat irritation that may interfere with normal activity, and xii) odours.

Although policy-making bodies make every effort to reduce ambient concentrations to levels below guidelines, it should be noted that these guidelines are not equated with safe levels of particulate air pollution. Studies has shown that there is no established low-end threshold for particulate air pollution, and for this reason, the WHO has set no zero-effect guideline for health effects associated with ambient long-term exposure to PM. The cumulative global health impacts of PM exposures continue to be significant: recent research estimates that 800,000 annual premature deaths globally are associated with PM air pollution exposures in excess of health guidelines (9-11).

Having as base other results referenced and used here as support for methodological development of this article, we conclude that the evidence of the health effects of different air pollutants has emerged from specific epidemiological analysis based on routinely collected health monitoring data on mortality and morbidity. At the air pollution levels currently occurring in typical developed countries, it is likely that data from long time periods have to be used to establish with statistical significance a change in population health status associated with changes in air pollution. A system that monitors seasonal changes in health and air pollution may be feasible in certain locations (24-26), but the monitoring of daily or weekly changes is likely to work in relatively severe pollution situations, and our results show be relevant elect PM_{10} as an indicator that express acute symptoms in urban monitoring.

Environmental air mitigation measures are prudent at all construction. Upwind and downwind monitoring stations should be determined on a daily basis. Limited air monitoring by conventional particulate sampling procedures are recommended to orient PM_{10} concentrations migrating off-site and contaminant levels. There are several alternative ways to improve urban air quality, apart from the technological measures which have been considered in relation to national emissions, and included in national cost curves for integrated assessment with respect to transboundary air pollution (28,29). However, in Rio de Janeiro we can observe, the emphasis in strategies to achieve air quality objectives is focused on limited areas of high concentration where high levels occurs, especially close to major roads. As such it is likely to have important effects on overall municipal emissions, and in some cases may even lead to necessary interventions on urban emissions.

CONCLUSION

1. The goals of this study were thus to assess the health effects of air pollution and to provide information about its local effects to the public. Accordingly, we sought to assess the public health impact of both acute (with short-term effects) and chronic (with long-term effects) exposure to PM_{10}.
2. This study proves data others where the PM_{10} is the pollutant principal associated with mortality and morbidity (hospital admissions) for local people. The results show that air pollution, even at moderate levels below the current recommended standards, affects the population's health.
3. The levels showed association with the hospital internments for respiratory disorders in seniors above 60 years in the same day and with the mortality in the same age group being these of more expressive magnitude in children. Evidencing the respiratory symptoms in children with an excellent indicator for significant increases of hospital admissions (figures 4 and 5).
4.. The epidemic data express the count of some

event of health along the time, in function of a factor or a group of factors, which can also be observed along the time. Such associations between the variable answer and exhibition, properly controlled by the variables that can confuse the estimate of the effect measure, they allow the estimate of the magnitude of the deleterious effects of the risk factors in the levels of the variable answer, and therefore that the impact of the exhibition is evaluated in subject for the public health.

5.. The use of PM network to assess exposure undoubtedly results in optimal reliable estimates. However there are necessities monitoring the air in areas representative of others actual realities, and this way obtain air quality measurements more representatives.

REFERENCES

1. **Duchiade MP.** Poluição do Ar e Doenças Respiratórias: Uma Revisão. Cad Saúde Públ 1992; 8: 115-37.
2. **Strum M, Cook R, Thurman J, Ensley D, Pope A, Palma T**, *et al*. Projection of hazardous air pollutant emissions to future years. Sci Tot Environ 2006; 366(2-3): 590-601.
3. **Latha KM, Highwood EJ.** Studies on particulate matter (PM_{10}) and its precursors over urban environment. J Quant Spectr Rad Trans 2006; 101(2): 367-79.
4. **Maia LFPG.** Avaliação das Variações Climáticas no Estado do Rio de Janeiro. In: Índice de Qualidade dos Municípios – Verde II. Fundação CIDE, Governo do Estado do Rio de Janeiro; 2003.
5. **Xiao F, Brajer V, Mead RW.** Blowing in the wind: The impact of China's Pearl River Delta on Hong Kong's air quality. Sci Tot Environ 2006; 367(1): 96-111.
6. **Castro HM,Gouveia N, Escamilla-Cejudo JA.** Methodological issues of the research on the health effects of air pollution. Rev. Bras. Epidemiol 2003; 6(2):135-49.
7. **Williams M.** Air pollution and policy: 1952–2002. Sci Tot Environ 2004; 334-335: 15-20.
8. **Evans MF, Smith VK.** Do new health conditions support mortality–air pollution effects? J Environ Econ Manag 2005; 50(3): 496-518.
9. **Harrison RM.** Key pollutants: airborne particles. Sci Tot Environ 2004; 334-335: 3-8.
10. **Lim LL, Hughes SJ, Hellawell EE.** Integrated decision support system for urban air quality assessment. Environ Mod & Soft 2005; 20(7): 947-54.
11. **Oudinet JP, Méline J, Chełmicki W, Sanak M, Magdalena DW, Besancenot JP**, *et al*. Towards a multidisciplinary and integrated strategy in the assessment of adverse health effects related to air pollution: The case study of Cracow (Poland) and asthma. Environ Poll 2006; 143(2):278-84.
12. **Carvalho AC, Carvalho A, Gelpi I, Barreiro M, Borrego C, Miranda AI**, *et al*. In uence of topography and land use on pollutants dispersion in the Atlantic coast of Iberian Peninsula. Atmosph Environ 2006; 40(21): 3969-82.
13. **Organización Mundial de la Salud.** Guías para la calidad del aíre. OMS: Genebra; 2000.
14. **United Nations Environmental Program.** Integrating Environment and Development: 1972 - 2002. pp. 1-27. In: Global Environmental Outlook 3 - Past, Present and Future Perspectives. London: Earthscan Publications; 2002.
15. **OECD.** Core Set of Indicators for Environmental Performance Reviews. A synthesis report by the Group on the State of the Environment. OECD Environment Monographs No. 83. OCDE/GD(93)179. OECD, Paris; 1993.1-39p.
16. **Filleul L, Zeghnoun A, Cassadou S, Declercq C, Eilstein D, Tertre A**, *et al*. In uence of set-up conditions of exposure indicators on the estimate of short-term associations between urban pollution and mortality. Sci Tot Environ 2006; 355 (1-3): 90-7.
17. **Wang X, Mauzerall DL.** Evaluating impacts of air pollution in China on public health: Implications for future air pollution and energy policies. Atmosph Environ 2006; 40(9): 1706-21.
18. **WORLD HEALTH ORGANIZATION (WHO)**. Environmental health indicators: environmental health indicators: development of a methodology for the WHO European region; 2001.
19. **Corvalán CF, Kjellstrom T, Briggs DJ.** Health and Environment Indicators in Relation to Sustainable Development. In: Moldan M, Billharz S. Sustainability Indicators – Report of the Project on Indicators of Sustainable Development, Scientific Committee on Problems of the Environment (SCOPE), Wiley; 1997.
20. **Corvalán CF, Kjellström T, Smith KR.** Health, Environment and Sustainable Development. Identifying Links and Indicators to Promote Action. Epidemiol 1999; 10:656-60.
21. **Castro HA, Gouveia N, Escamilla-Cejudo JA.** Methodological issues of the research on the health effects of air pollution. Rev Bras Epidemiol 2003;6(2): 135-49.
22. **Donaldson K, Gilmour MI, MacNee W.** Asthma and PM_{10}. Respir Res 2000;1:12–15.
23. **Boyce JK, Klemer AR, Templet RH, Willis CE.**

Power distribution, the environment, and public health: A state-level analysis. Ecol Econ 1999; 29:127-140.

24. **Brown P, B Mayer, S. Zavestoski, T Luebke, J Mandelbaum, S McCormick.** The health politics of asthma: environmental justice and collective illness experience in the United States. Soc Sci & Med 2003; 57:453-64.
25. **Mediavilla-Sahagún A, ApSimon HM.** Urban scale integrated assessment for London: Which emission reduction strategies are more effective in attaining prescribed PM_{10} air quality standards by 2005? Environ Modell & Soft 2006; 21(4): 501-13.
26. **Maantay J.** Zoning, Equity, and Public Health. Am J Pub Heal 2001; 91:1033-41.
27. **Evans GW, Kantrowitz E.** Socioeconomic status and health: the potential role of environmental risk exposure. Annu Rev. Pu Heal 2002; 23:303-31.
28. **Morello-Frosch R, Pastor Jr M, Porras C, Sadd J.** Environmental Justice and Regional Inequality in Southern California: Implications for Future Research. Environ Heal Perspect 2002; 110(Suppl 2):149-54.
29. **Culshaw MG, Nathanail CP, Leeks GJL, Alker S, Bridge D, Duffy T**, *et al*. The role of web-based environmental information in urban planning: the environmental information system for planners. Sci Tot Environ 2006; 360(1-3): 233-45.