

Human exposure assessment to arsenic and health indicators in Paracatu, Brazil

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ABSTRACT: We conducted a descriptive epidemiological study to assess the human exposure and health effects due to possible arsenic exposure from an open pit golden mine operating in Paracatu. Two subpopulations were assessed regarding hair, urine and blood arsenic concentrations: one living in the region bordering the gold mining operation activities and the other living around 5 km distant from the gold mining process. Statistical significant differences were found in urinary arsenic levels between the two subpopulations, considering plain results in $\mu\text{g L}^{-1}$ and normalized by urinary creatinine concentrations ($p < 0.0001$). However, both means showed to be in the interval of reference values for an urban Brazilian population. Cancer mortality and dermatological morbidity were also evaluated. Results showed that cancer mortality from cancers usually related to arsenic chronic exposure to be in or below the expected background indexes. No typical arsenicosis dermatopathies were found. Hair samples are still under analysis.

1 INTRODUCTION

Several health effects can result from inorganic arsenic chronic exposure, consisting of carcinogenic and non-carcinogenic conditions (Obiri *et al.*, 2006; Pearce *et al.*, 2012). For both kinds of effects, a long period of time is necessary from the start of the exposure and the diagnosis, depending, in this context, on the level of exposure. The most frequent and early non-carcinogenic effect is related to changes in skin (Guha Mazumder, 2000). Also related to the skin is the most prominent carcinogenic effect (multiple basocellular, multiple epidermoid carcinomas, and Bowen's disease).

Studies of health effects due to environmental exposure to As have been published mostly in populations ingesting arsenic contaminated water, like in Chile, Argentina, Bangladesh, West Bengal, and Taiwan. Arsenic inhalation studies are uniquely restricted to the occupational set where deleterious effects have been described in high inhalatory doses. In this respect, related studies have shown that arsenic inhalation is responsible for less than 1% of the total absorbed dose due to

non-occupational environmental contamination (ATSDR, 2007).

The objective of this study was to evaluate the human exposure to As in a population living near to an open pit gold mining in Paracatu, MG, Brazil. Results from drinking water sources used by the population showed very low levels of As, all of them below 2 mg L^{-1} (Bidone *et al.*, 2014), indicating potentially no concerns on this exposure pathway. On the other hand, the mine operates in an open pit process involving the production of dust potentially contaminated by As. Results of As in particulate matter in the atmosphere indicate that dusts can reach residential areas of the city, which might contaminate the air and can be an additional source to the surrounded soil (Zamboni *et al.*, 2014).

2 POPULATION AND METHODS

Paracatu is situated in the northwest of MG, with an economy tied to the agricultural and mining sectors (gold, zinc and calcareous). The city had

84,687 inhabitants in 2010 (1.7% annual increase rate) and a Human Development Index of 0.760 (IBGE, 2010).

A descriptive epidemiological study was conducted to assess human exposure and health effects through three complementary approaches: a) population sampling following an epidemiological design which took into account two geographically distinct communities: one living in the region bordering the study area and the other living around 5 km distant from the gold mining process (control area); b) dermatological evaluation of suspected cases previously selected by the public health care system team; c) mortality data analysis regarding cancers known to be associated to chronic arsenic exposure. Urine, blood and hair samples were collected from adults older than 40 years and living in the areas for more than 20 years, a population thought to be the most sensitive to chronic exposure to low arsenic doses. As analyses in urine and blood was done by GF-AAS. Mortality data from lung, urinary bladder, liver and skin cancers from Paracatu of 2000 (not shown here) and 2010 were collected from the Ministry of Health official data bank (DATASUS) and compared with data from cities with similar demographic structure, with gold mining activities (Nova Lima) and without (Três Corações and Itajubá). Comparisons were also made with data from the state of Minas Gerais (MG), and Brazil as a whole. The epidemiological study was approved and registered at the National Commission for Ethics in Research (CONEP/CAE 04328912.0.0000.0019).

3 RESULTS AND DISCUSSION

Cancer mortality was analyzed regarding four kinds of cancers associated to As exposure: lung, liver, urinary bladder and skin, despite the fact that skin cancers, besides melanoma (not involved in cases of As exposure), have very low mortality. Table 1 shows the distribution of mortality rates by 100,000 inhabitants in 2010, and compared with rates from MG and Brazil as a whole. Table 1 shows that the mortality rates in Paracatu regarding lung, liver and urinary bladder cancers are in the same magnitude compared with other cities, MG and Brazil as a whole. There is no indication of increased rates in Paracatu regarding these pathological conditions.

As most cases of lung cancer cases are fatal within five years, relative risks for incidence and mortality are approximately the same.

A preliminary survey of dermatopathies was carried out using the local health care system represented by two of the public Family Medicine Health Services (PSF: Programa de Saúde da Família),

Table 1. Mortality rate by 100,000 in Paracatu compared with 3 cities with similar demographic structure and with MG and Brazil in 2010.

Organ	PCT	NL	TC	ITJ	MG	Brazil
Lung	10.5	19.7	12.4	11.0	9.5	14.0
Liver	3.5	6.1	1.3	6.6	3.5	4.0
UB	1.2	NA	1.3	1.1	1.5	1.6
skin	NA	NA	NA	1.1	0.6	0.8

PCT: Paracatu; NL: Nova Lima; TC: Três Corações; ITJ: Itajubá; MG: Minas Gerais; UB: Urinary Bladder; NA: Data Not Available.

responsible for the care of two geographically distinct communities: one living in the region bordering the mining pit (referring to Amoreiras PSF), and the other living around 5 km distant (Paracatuzinho PSF). Adult patients with any chronic dermatopathy were examined by the two physicians from the researchers group (EMDC and IMJ). The diagnostic approach was based in the peculiar clinical presentation of the possible dermatopathies related to arsenic chronic exposure published elsewhere (Guha Mazumder, 2000). Thirty patients from the study area, and fourteen patients from the control area were minutely examined. No lesions suspected to be associated to arsenic chronic exposure were seen in any of them. Although no significant differences were observed between blood As levels in the two subpopulations studies ($p = 0.42$), they were detected in urinary As levels, indicating that people living close to the mining site are more exposed to As. Nevertheless, urinary As mean and median values, for both groups, showed to be in the interval of reference value for a urban Brazilian population ($4.04 \mu\text{g L}^{-1}$ SD: 2.01), as well as to the mean ($8.10 \mu\text{g L}^{-1}$; $7.44\text{--}8.83 \mu\text{g L}^{-1}$) and median ($7.49 \mu\text{g L}^{-1}$; $6.90\text{--}8.12 \mu\text{g L}^{-1}$) of As in urine from US population (CDC, 2012).

4 CONCLUSIONS

Despite the spatial relationship between the gold mine operating in full capacity during the last years, and the communities living in the vicinity, potentially exposed to As contaminated dust, health effects secondary to that exposure showed to be negative regarding specific carcinogenic and skin diseases, considered to be associated to inorganic chronic arsenic exposure. However, the differences between the mean and median urinary arsenic concentrations of the two subpopulations is likely to be related to the proximity of Amoreiras with the mining activities, promoting a heavier As airborne exposure in this locality compared to Paracatuzinho.

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