Available online at www.sciencedirect.com
SCIENCE DIRECT®
Environment International 32 (2006) 493 – 499
ENVIRONMENT INTERNATIONAL
www.elsevier.com/locate/envint

Community mercury levels in the vicinity of peri-urban waste disposal sites and fossil fuel burning operations

Mohamed A. Dalvie *, Rodney Ehrlich [1]

Occupational and Environmental Health Research Unit, School of Public Health and Family Medicine, Health Sciences Faculty, University of Cape Town, Anzio Road, Observatory, 7925, Cape Town, South Africa

Received 2 August 2005; accepted 22 November 2005
Available online 24 January 2006

Abstract

Introduction: A study was conducted as a result of concern about mercury absorption amongst residents of a peri-urban area in Cape Town, South Africa, in close proximity to waste disposal sites and an industrial area.
Study methods: The study compared urine mercury concentrations in a random sample of adult residents and children in both the formal and informal housing settlements of the “exposure” area ($n=90$) and a control area ($n=90$). A short questionnaire elicited demographic, lifestyle and medical details and possible occupational, household and environmental mercury exposures.
Results: The two samples were comparable with respect to background and potential confounding variables. The prevalence of urinary mercury levels ≥ the WHO reference range in the exposure area was also higher than that in the control area (13% vs. 0%). The median urinary mercury concentrations in both study areas were below the World Health Organisation (WHO) reference level of 5.0 μg/g creatinine. The median level in the exposure area was slightly, but statistically significantly, higher than in the control area (1.1 vs. 0.25 μg/g creatinine), and the excess persisted after controlling for known possible mercury exposures.
Conclusions: This is to our knowledge the first study of community inorganic mercury absorption in a developing country setting, and where airborne mercury was the exposure of concern. It was concluded that the health risk associated with the urinary mercury levels of residents in the exposure area was very low. However, low level environmental exposure in the area of concern could not be excluded.

Keywords: Urinary mercury; Environmental; Atmospheric; Inorganic; Peri-urban; Developing country; Industry; Waste

1. Introduction

This study arose out of a concern about mercury absorption amongst residents of a peri-urban area in Cape Town, South Africa living in close proximity to waste disposal sites and a small industrial site. The residential area includes a high income formal settlement and low-income, unserviced (informal) settlements that are common in developing countries. Independent surveys commissioned by the residents found excessive levels of mercury absorption among some residents (Kuhn, 2003). Possible sources of mercury in the area identified by residents included products of the incineration and treatment of waste at a municipal waste site (which services low to medium hazardous waste), a medical waste incineration site and a municipal landfill site (which services hazardous waste). Another source of concern was the burning of fossil fuels (coal and oil) at a brick factory and an oil reclamation plant potentially resulting in airborne mercury as particulate or vapour. In addition, there was daily waste picking on the waste sites by residents of the informal settlements in the area. Mercury exposure through drinking water was considered unlikely as the water sources are situated outside the area. Localised methyl mercury pollution was also regarded as unlikely as there are no waterways as a source of fish in the area.

In response to the residents' concerns a government task team was set up to work with the community and local industry. Two private environmental health consultants called upon by

* Corresponding author. Tel.: +27 21 4066610; fax: +27 21 4066163.
E-mail address: aqiel@cormack.uct.ac.za (M.A. Dalvie).
[1] Tel.: +27 21 4066610; fax: +27 21 4066163.

0160-4120/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.envint.2005.11.003

the task team concluded that the mercury concentrations in dust measured in the residents' study was low. There was also no evidence of groundwater mercury pollution and no data on ambient air concentrations of mercury were available (Schoeman, 2003; Van Niekerk et al., 2003). A number of methodological problems with the residents' study were identified, including the non-random selection of study subjects and the failure to inquire about other potential sources of mercury such as dental amalgams and fish eating (Barregard, 2004). An epidemiologic study was thus requested to determine (1) the levels of mercury absorption by residents and (2) whether these were higher than in a comparable area of Cape Town with less industrial activity and no waste site. Unlike in other community studies that investigated either environmental methyl mercury pollution or indoor mercury pollution (Barregard, 2004; International Programme on Chemical Safety (IPCS), 1989, 1990a,b, 1991; Tsuji et al., 2003), it was outdoor airborne mercury pollution that was the source of community concern in this investigation.

The urinary mercury concentrations of residents were measured as these are considered to be the most accurate biomarker for the absorbed dose from chronic exposure to mercury vapour and inorganic mercury and have been shown to correlate with levels in air (Apostoli et al., 2003; Bjornberg et al., 2003; IPCS, 1990b). In contrast, blood and hair mercury concentrations are more suitable biomarkers of methyl mercury absorption (IPCS, 1990a; Oosthuizen and Ehrlich, 2001; Tsuji et al., 2003).

One of the problems in conducting such a study was that South Africa has no community urinary reference value for mercury, only an occupational standard (Table 1). Also, no study investigating the impact of environmental atmospheric mercury on community urinary mercury levels could be found in the literature. The World Health Organisation (WHO) has set a community urinary mercury reference and upper bound value based on the median and 90th percentile level amongst international communities (Table 1). The Human Biomonitoring Commission of the German Federal Environmental Agency (Wilhelm et al., 2004) has based their more stringent but no-action reference value on the 90–95th percentile amongst European communities and additionally has an alert (biological monitoring) level and an action level (Table 1).

Table 1
Urinary mercury reference values

Organisation	Reference value (μg/g creatinine)
WHO (IPCS, 1991; WHO, 1996)	4–5
Biological exposure index (occupational), (Department of Health, RSA, 1993)	35
Human Biomonitoring Commission of the German Federal Environmental Agency (Wilhelm et al., 2004):	
Reference value (without amalgam fillings)	1
Human biological monitoring level	5

IPCS: International Programme on Chemical Safety.
RSA: Republic of South Africa.
WHO: World Health Organisation.

2. Study methods

2.1. Subjects

A representative cross-sectional study of adult residents and children in the Vissershok ("exposure") and Noordhoek ("control") areas of Cape Town was conducted to determine mercury absorption. Both are peri-urban areas with a mix of industrial and commercial activities.

Sample size calculations were based on a projected mean urinary mercury levels of 12 μg/g creatinine among the exposed (close to the mean of 12.7±15.9 μg/g creatinine found in the residents' study) and a mean of 5 μg/g creatinine amongst controls (corrected assuming 1 g creatinine per L), and a standard deviation of 15.9 μg/g creatinine. Sample sizes of 83 each for control and exposure groups were required for an alpha of 0.05 and a power of 80%. Ninety participants each from the exposure and the control area were selected, a quarter of whom were children aged below 15 years of age.

The sample from the exposure area was drawn from the formal settlement comprising about 50 households and a population of 200 residents, and from four informal settlements comprising about 250 households and 900 residents, all situated within one kilometer of the industrial area. The informal settlements consist of poor, mostly unemployed communities who live in galvanized iron shacks, have non-flush outdoor sanitation facilities, use municipal water delivered by truck in containers supplied by the residents and use paraffin (domestic kerosene) as a cooking fuel. Waste picking is common amongst these residents and more than half live within 100 m of the industrial site. A total of 40 participants in the formal settlement and 50 in the informal settlements were chosen so as to have enough formal settlement residents to make comparisons. Households in the formal area were selected by systematic random sampling, while in the informal settlements households were proportionally stratified according to population density per settlement and then chosen by systematic random sampling. One participant per selected household was chosen. If there were no participants in the selected households, the sequence was to select the next household, followed by the one before, followed by that two households ahead, etc.

The control area had only light industrial and retail activity. There were no waste facilities nor industries burning fossil fuel. Its formal area with about 50 households and a population of 200 residents and the two nearby informal sites with approximately 1030 people were selected to constitute the control population. A sample of 40 residents in the formal area and 50 in the informal areas was chosen in the same manner as in the exposure area.

Exposure assessment was based on urinary mercury concentration measurements and a short questionnaire.