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Risk Factors for Increased Urinary Cadmium Levels among a Rural Population Living Near a Dumpsite in the Deli Serdang District of Indonesia

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Abstract

Cadmium (Cd) is a toxic mineral, which occurs naturally in the environment and as a result of agricultural and industrial activities. It is also a carcinogenic heavy metal. After exposure, Cd accumulates in the kidney and is excreted in urine. The urinary Cd level is considered a biomarker of long-term exposure to the mineral. The aim of this study was to analyze the association between urinary Cd levels and sociodemographic characteristics of a rural population living close to Namo Bintang dumpsite. This study used a cross-sectional design and consisted of 99 participants, which were selected using the stratified random sampling method according to the distance from their homes to the dumpsite area. Urinary Cd levels were measured at baseline using a graphite furnace atomic absorption spectrophotometer and normalized by urinary creatinine. Demographic data and exposure to Cd-related risk factors were obtained through a direct interview using a questionnaire. The urinary Cd level of all the participants exceeded guidelines (>5 μg/g creatinine) according to the biological exposure indices of The American Conference of Governmental Industrial Hygienists (ACGIH). The presence of a smoking habit was significantly associated with increased urinary Cd levels ($p = 0.041$). It can be concluded that the community living close to the dumpsite has been exposed to Cd, which was related to urinary Cd levels.

Keywords: cadmium; urinary Cd; heavy metal; dumpsite

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1. INTRODUCTION

In Indonesia, the disposal of waste in open dumps rather than in landfill sites remains the predominant method of waste management [6]. The disposal of waste in open dumps has the potential to pollute the environment, including contamination of groundwater by leachate [6]. This leachate may contain organic materials and heavy

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metals, such as cadmium (Cd) [8, 11]. Cd in landfill is derived from plastics, batteries, and waste from industry (e.g., steel) [5].

Cd is released into the environment in wastewater. Diffusion pollution from fertilizers and local air pollution represents an additional source of Cd. Contamination of drinking water with Cd may occur as a result of impurities in zinc galvanized pipes, solders, and various types of metal fittings [17].

Food is the main source of daily exposure to Cd. Cd contamination in a range of vegetables, including radishes, cress, dill, spinach, and eggplants, has been reported [18]. The daily oral intake of Cd was reported to be 10–35 μg [18]. Smoking is a significant additional source of Cd exposure [17]. Cd has highly toxic effects, even at low concentrations; furthermore, it cannot be degraded by living organisms and therefore accumulates in the environment (ATSDR 2008; [15, 18]). Exposure to Cd in the environment can increase the incidence of various types of cancers, such as lung, prostate, kidney, endometrial, breast, and stomach [10]. Exposure to Cd also increases the risk of cardiovascular disease [12].

Urinary Cd levels have been shown to accurately reflect the amount of Cd in the body, both past and present exposure. Cd levels in blood reflect recent exposure. The aim of this study was to analyze the association between urinary Cd levels and sociodemographic characteristics of a rural population living close to Namo Bintang dumpsite.

2. METHODS

This was a cross-sectional study of a rural community living close to Namo Bintang dumpsite in the Deli Serdang District, North Sumatra Province, Indonesia. The study included all females and males aged ≥ 18 years who had lived close to the study site for at least 7 years and were willing to provide urine samples and to be interviewed.

Spot urine samples were collected from the participants in the morning. The samples were analyzed using a Z-5700 polarized Zeeman graphite furnace atomic absorption spectrophotometer. The Cd concentration in the samples was determined using standard methods.

2.1. Statistical Analysis

Kolmogorov–Smirnov and Shapiro–Wilk tests were conducted and indicated that the data were not normally distributed. Spearman's correlation test was performed to evaluate the association between age and urinary Cd levels.

3. RESULTS

As shown in Table 1, the urinary Cd level of the participants normalized to creatinine ranged from 6.1 to 206.1 μg/g creatinine, with an average of 35.15 μg/g (SD ± 32.65 μg/g creatinine).

TABLE 1: Descriptive Statistics of Urinary Cd Levels.

Variable	Mean	Median	SD	Min-Max	95% CI
Urinary Cd (μg/g creatinine)	35.15	22.37	32.65	6.1–206.1	28.6–41.7

Table 2 shows the demographic characteristics of the participants (n = 99). The ages of the participants ranged from 19 to 75 years. The average age was 42.32 years (SD ± 13.07 years). There were 26 men and 73 women, of whom 10.1% had occupational exposure to Cd. In the study, 40.4% of the participants were smokers, and 59.6% were nonsmokers. Most of the participants were not obese.

TABLE 2: Demographic Characteristics of the Participants.

Variable	
Age	
Mean ± SD	42.32 ± 13.07
Min–Max	19–75
Variable	Frequency (%)
Sex	
Men	26 (26.3)
Women	73 (73.7)
Occupational exposure to Cd	
Not exposed	89 (89.9)
Exposed	10 (10.1)
Smoking habit	
No	59 (59.6)
Yes	40 (40.4)
BMI	
Obese	29 (29.3)
Non Obese	70 (70.7)

3.1. Age and Urinary Cd levels

As shown by the results of Spearman's correlation test, there was a weak but significant correlation between age and urinary Cd levels (r = 0.158, p = 0.117) (Table 3).

Table 3: Correlation between Age and Urinary Cd Levels.

Variable	Mean (SD)	Correlation Coefficient	p value
Age	42.32 (13.07)	-0.158*	0.117

3.2. Demographic Characteristics of the Participants and Urinary Cd Levels

There was no significant association between the urinary Cd levels and sex, occupation, and body mass index (BMI) of the participants (Table 4). However, there was significant association between urinary Cd levels and smoking habits (p = 0.041).

Table 4: Demographic Characteristics of the Participants.

Variable	n	Mean	SD	p value
Sex				0.135
Men	26	25.37	16.92	
Women	73	38.63	36.13	
Occupational exposure to Cd				0.134
Not exposed	89	32.41	27.46	
Exposed	10	59.50	59.19	
Smoking habit				0.041
No	59	30.04	24.27	
Yes	40	42.68	41.30	
BMI				0.489
Obese	29	44.45	44.85	
Not obese	70	31.29	25.43	

4. DISCUSSION

4.1. Age and Urinary Cd Levels

According to a previous report, when exposure to Cd remained constant, the content of Cd in the body increased with aging until age 50–60 years, in addition to renal accumulation of Cd (ATSDR, 2008). In the present study, age was not significantly associated with urinary Cd levels (p = 0.117). This finding is consistent with that reported in an earlier study, which also found no significant association between age and urinary Cd levels ($p > 0.05$) [13].

4.2. Sex and Urinary Cd Levels

In contrast to most environmental pollutants, where the burden is higher in men than in women, women have a higher body burden of Cd [16]. Vahter et al. (2007) reported higher concentrations of Cd in blood, urine, and kidney cortex of women as compared to men. The main reason for the higher Cd burden in women is increased intestinal absorption of dietary Cd when iron stores of the body are low. In the present study, there was no significant association between sex and urinary Cd levels. This finding can be explained by the study population, which did not include menstruating or pregnant women or those with malignancies and kidney diseases, all of which can increase Cd levels in the body.

4.3. Occupation and Urinary Cd Levels

The results of the present study differed from those reported in a previous study in Thailand by Sirivarasai (2002), who found that the blood concentration of Cd in the general population was lower than that of individuals with occupational exposure to Cd. According to a previous report, in workers with occupational exposure to Cd, urinary Cd excretion increased in accordance with the accumulation of Cd in the body [2]. However, in the absence of kidney damage, the amount of Cd that was excreted accounted for only a small part of total Cd [2].

4.4. Smoking Habits and Urinary Cd Levels

In the present study, the results of the Mann–Whitney test pointed to a significant association between smoking habits and increased urinary Cd levels ($p = 0.041$). This significant association could be explained by the long half-life of Cd. As reported in a previous study, the concentration of Cd in urine increased in the presence of smoking habits because of the long half-life (10–30 years) of Cd. According to one study, the urinary Cd concentration in smokers was two to four times higher than that in non-smokers [7]. Another study reported that when classified by the number of cigarettes smoked per day, the urinary Cd level in current smokers increased in accordance with the number of cigarettes consumed (about 0.09 μg/cigarettes/day), leveling off after

15 or more cigarettes [9]. However, a study of the amount of Cd absorbed in cigarette smokers and urinary Cd levels suggested that almost all the Cd absorbed was excreted in urine.

4.5. BMI and Urinary Cd Levels

The present study found no significant association between BMI and increased urinary Cd levels. This finding is in accordance with that of a previous study [14]. However, another study found a significant association between the BMI and urinary Cd levels [4].

5. CONCLUSIONS

This study found no association between urinary Cd levels and age, sex, occupation, and BMI. There was a significant association between smoking habits and urinary Cd levels. Thus, Cd exposure may be important in the development of tobacco-related lung disease.

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