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Urinary Cadmium and Albumin Levels among Residents Living Close to Dumpsite in the Deli Serdang District of Indonesia

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Abstract

Albuminuria is a pathological condition wherein the protein albumin is present in urine. Albumin levels can be used as biomarker of kidney damage caused by cadmium (Cd). Many factors influence albuminuria, including environmental conditions, lifestyle-related factors, and sociodemographic characteristics. This study examined the association of sociodemographic characteristics with both urinary Cd levels and urinary albumin levels among rural residents living close to a dumpsite in Namo Bintang village. This study used a cross-sectional design, and the study population consisted of adult men and women (n = 99) who were selected using the stratified random sampling method based on the distance from their homes to the landfill. The data were analyzed using Spearman's Rho and Mann–Whitney tests. Urinary albumin was determined using the urinary albumin (µg)/creatinine (mg) ratio, and urinary Cd levels were normalized to Cd (µg)/creatinine (g). Urinary albumin was measured by spectrophotometric and enzymatic analyses. Urinary Cd levels were determined using a graphite furnace atomic absorption spectrophotometer in spot urine sampled at baseline. The characteristics of the participants, such as age, body mass index (BMI), sex, Cd exposure, occupation, and smoking status, were obtained through a direct interview using a questionnaire. The average urinary albumin level was 8.69 ± 14.55 µg/mg creatinine, and the average urinary Cd level was 35.1 ± 32.65 µg/g creatinine. Women had a higher risk than men of having albumin in their urine, pointing to an association between sex and urinary albumin levels (p = 0.041). Based on the findings of this study, local government officials should advise rural residents in dumpsite areas not to use well water for drinking and to check the water quality regularly to prevent urinary disease.

Keywords: Albuminuria, Urinary Cadmium, Dumpsite

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1. INTRODUCTION

Cadmium (Cd), a heavy metal commonly found in the environment, has highly toxic effects, even at low concentrations [1]. Open dumping waste management landfill methods provide a source of anthropogenically produced Cd. When leachate water from the biodegradation of household waste seeps into the ground, it can contaminate the well water of communities who live in areas close to the landfill [4, 12]. Communities who consume water from contaminated wells water with a high concentration of Cd are at risk of nausea, vomiting, diarrhea, and death. The consumption of low concentrations of Cd over long periods results in Cd accumulation in the kidney and eventually kidney damage [6].

A urinalysis can be used as a diagnostic tool in kidney disease, urinary tract infections, and metabolic disorders not involving the kidneys [14]. Urine is excreted by the kidneys, stored in the bladder, and expelled through the urethra. Arain et al. (2015) reported a high correlation between the concentration of arsenic in water and Cd in blood and urine samples of patients with renal impairment compared with patients without renal impairment. Protein in urine can also be an early sign of kidney disease, both existing and asymptomatic. Normally, only a small fraction of plasma protein is filtered through the glomerulus, and protein absorption then occurs in the tubules [28]. Thus, in healthy individuals, no plasma protein is present in urine [28].

Albumin is a negatively charged protein, which is almost entirely inhibited by the glomerular cell wall. Albumin experiencing the glomerular filtration membrane. Urinary album excretion increases when the glomerular albumin filtration process exceeds the capabilities of tubular reabsorption [15]. Albuminuria, which refers to the presence of albumin in urine, is an early clinical biomarker of kidney damage. A previous study reported that low levels of Cd in urine were associated with albuminuria in a diabetes population in Australia [10]. In a 5-year follow-up study conducted in Belgium (subcohort from the Cadmibel Study), the authors reported that the urinary Cd concentration changed the association with albuminuria [11].

The open dumping method has been operated for years at a landfill site close to Namo Bintang village in the Deli Serdang district, raising the risk of leachate contamination. Although the landfill has been closed since 2013, leachate can continue long after (20–30 years) landfill closure (Thobanoglous and Theisen 1993; [25]). Furthermore, the community in Namo Bintang continues to use a regional landfill, which is located within a radius of 100 meters [5].

According to Republic of Indonesia Health Ministerial Decree No. 416/Menkes/Per/IX/1990 on water quality standards, the concentration of Cd should not exceed 0.005 mg/L. Research showed that well water in Hamlet I, which is located within a radius of 200 m to the west of the Namo Bintang village landfill, contained Cd and that the level exceeded water quality standards [20]. In an analysis of water from 30 wells, the lowest concentration was 0.213 mg/L (i.e., 42.6 times higher than the standard), and the highest concentration was 0.531 mg/L (i.e., 106.2 times higher than the standard) [20].

The present study aimed to determine the association between urinary Cd levels and urinary albumin levels among rural residents living close to a dumpsite in Namo Bintang village.

2. METHODS

This study used a cross-sectional design. The variables included were urinary Cd levels, characteristics of the study population (age, body mass index [BMI]), sex, Cd exposure, occupation, and smoking status), and urinary albumin levels. The study population consisted of adult males and females aged 18 years and older who had lived at least 7 years in the area surrounding the Namo Bintang dumpsite in the Pancurbatu subdistrict, Deli Serdang district, North Sumatra.

In total, 99 individuals were selected for inclusion in the study based on stratified random sampling according to the distance from their homes to the landfill. The selected area included residents living within a radius of <1 km and >1 km from the dumpsite. Additional inclusion criteria were the use of well water from the study site as the primary source of water for drinking and cooking and no chemical treatment of the well water.

Urinary albumin was measured by spectrophotometry (albumin) and enzymatic (creatinine) methods using automated chemical analysis tools. The ratio of albumin to creatinine (ACR) was calculated by predicting 24-h urinary albumin excretion (µg/mg creatinine) in urine samples in 24-h period [18]. Urinary Cd levels were measured using a Z-5700 polarized Zeeman graphite furnace atomic absorption spectrophotometer and normalized by urinary creatinine (µg/g). Sociodemographic data were obtained through a direct interview using a questionnaire. The study was approved by the Health Research Ethical Committee of the Universitas Indonesia (No. 230/UN2.F10/PPM.00.02.2016).

3. RESULTS

The average of age of the participants was 42 years (SD ± 13 years). The BMI of the participants ranged from 15.92 kg/m^2 to 34.48 kg/m^2, with an average of 23.33 kg/m^2 (SD ± 3.88 kg/m^2). The majority of the participants were women (73.7%). In the study population, 89 (89.9%) participants had no occupational Cd exposure, and 59 (59.6%) participants had no smoking history (59.6%) (Table 1).

The average urinary albumin level was 8.69 µg/mg creatinine (SD ± 14.55 µg/mg creatinine), which is lower than the normal <30 µg/mg creatinine level (National Kidney Disease Education Program, 2010). The average urinary Cd level ranged from 6.09 µg/mg creatinine to 206.14 µg/mg, and the mean was 35.1 µg/mg creatinine (SD±32.65 µg/mg creatinine) (Table 2). All the participants (100%) had higher than normal urinary levels of Cd according to limits set by the American Conference of Governmental Industrial Hygienists (ACGIH) (<5 mg/g creatinine).

There was a no correlation and a negative association between urinary levels of Cd and urinary levels of albumin. Age showed a positive association with albumin levels, although the correlation was not statistically significant. There was no correlation between the degree of albuminuria and age but a positive association. The average urinary albumin levels of men and women differed. The results of the statistical analysis revealed no significant difference in the average urinary albumin levels of individuals with and without occupational Cd exposure (Table 3).

Table 1: Sociodemographic Characteristics of the Study Population.

Variable	Mean ± SD	Minimum-Maximum
Age(years)	42.32 ± 13.07	19–75
BMI (kg/m^2)	23.33 ± 3.88	15.92–34.48
Variable	Frequency	Percentage (%)
Sex		
Male	26	26.3
Female	73	73.7
Occupational Cd exposure		
Exposed	10	10.1
Nonexposed	89	89.9
Smoking status		
Yes	40	40.4
No	59	59.6

Table 2: Urinary Albumin and Cd Levels.

Variable	Mean ± SD	Minimum-Maximum
Urinary albumin level (µg/mg creatinine)	8.69 ± 14.55	0–88
Urinary Cd level (µg/g creatinine)	35.1 ± 32.65	6.09–206.14

Table 3: Association of Sociodemographic Characteristics with Urinary Cd and Albumin Levels.

Variable	*r*-Value		p Value		
Urinary Cd	-0.145		0.152		
Age	0.141		0.165		
BM	0.062		0.544		
Variable	Mean	SD	Mean Rank	p value	n
Sex					
Male	6.58	14.29	40.19	0.041	26
Female	9.44	14.67	53.49		73
Occupational Cd exposure					
Exposed	13.80	23.82	44.55	0.524	10
Nonexposed	8.11	13.21	50.61		89
Smoking status					
Yes	10.80	21.07	45.34	0.181	59
No	7.25	7.36	53.16		40

4. DISCUSSION

4.1. Urinary Cd and albumin levels

There was no correlation and a negative association, although all the participants (100%) had higher than normal levels of Cd. These results are similar to findings presented by Noonan et al. (2002), who found no significant association between urinary Cd levels and urine albumin levels in smelter workers in the U.S. versus a comparison group of communities with a positive relationship. The findings of the present study differ from those of Akerstrom et al. (2013). They found a positive association between the excretion of urinary Cd and urinary albumin and attributed this to the long biological half-life of Cd in the human body [13]. Haddam et al. (2011) also reported an association between urinary Cd and urinary albumin levels and concluded that various factors, including smoking and diuresis, explained this association.

4.2. Age and urinary albumin levels

The present study found a positive association between age and urinary albumin levels. This finding is in line with that of a cross-sectional study by Robert et al. (2012), which found no correlation between age and albumin excretion ($p = 0.779$). In contrast, Chowta et al. (2009) reported that microalbuminuria was significantly associated with age. As reported by Pranandari and Supadmi (2015), decreased functioning of the kidney with aging can lead to tubular dysfunction and increased renal excretion rates. McClellan and Flanders (2003) concluded that older age was a risk factor for kidney failure

4.3. BMI and urinary albumin levels

This study detected no correlation between the degree of albuminuria and BMI. This result is in agreement with that that of a study by Nagel et al. (2013), which found no relationship between the BMI and albuminuria in women. It is in contrast to that of a study by Metcalf et al. (1992). They reported a significant correlation between the BMI and rate of excretion of albumin in men with type II diabetes

4.4. Sex and urinary albumin levels

The average urinary albumin levels of men and women differed in the present study. The mean urinary albumin level of the female participants was 9.44 µg/mg, whereas the mean value in the male participants was 6.58 µg/mg. The majority of the participants (73%) were females. Ashar (2015) also reported a significant sex-related difference in mean urinary albumin levels. However, the findings of the present study differed from those of other research, which found increased urinary excretion of albumin only in men [17]. In a urinalysis of female subjects, research on individual types of protein did not detect albumin. In women, increased excretion of proteins due to Cd toxicity usually occurs after menopause. Therefore, determining the effects of Cd toxicity in women and men aged <50 years with the same can camouflage the sensitivity of different types of proteins [4].

4.5. Occupational exposure to Cd and urinary albumin levels

In the present study, there was no difference in the average urinary albumin levels in individuals with and without occupational exposure Cd. This finding is in accordance with that of a study by Ashar (2015). Roels and Hoet (1999) reported that the exposure dose depended on amount of exposure to Cd in the workplace that can cause renal tubular dysfunction. Friberg (1984) reported that tubular dysfunction due to exposure to Cd resulted in increased excretion of albumin and low-molecular weight proteins. The finding of no significant association in the present study was likely influenced by the number of participants with and without occupational Cd exposure.

4.6. Smoking status and urinary albumin levels

In this study, there was no correlation between the average urinary albumin levels of smokers versus those of nonsmokers. The number of cigarettes consumed per day can influence urinary albumin levels. A previous study reported a dose-dependent association between cigarette smoking (more than 20 cigarettes/day) and albuminuria (Sietma et al. 2000). Another study reported that smoking increased the risk of renal functional impairment in the general population, particularly in men and the elderly (Orth et al. 1999)

5. CONCLUSIONS

In this study, urinary Cd levels did not affect urinary levels of albumin, although all the urine samples had Cd levels above normal limits set by the ACGIH. In addition, women had higher urinary albumin levels than men. The findings of this study should encourage local government to advise residents in the community living close to Namo Bintang dumpsite not to use well water for drinking and to check the quality of the water regularly to prevent disorders caused by leachate from the landfill. Further studies, including other urinary biomarkers of kidney damage, are needed.

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