Assessment of serum trace element levels of solid waste scavengers in Osogbo, South-western, Nigeria

Short title: waste scavenging and essential trace elements

ABSTRACT

The aim of the study was to determine whether altered serum trace element status is one of the occupational hazards associated with solid waste scavenging. Having obtained informed consent, 30 male solid waste scavengers (SWS) and 30 age-matched males which served as control group were recruited for the study. Trace elements were analyzed by Atomic Absorption Spectrophotometry from serum obtained from 5mL of blood collected from each participant. Questionnaire was administered to obtain information on lifestyles; degree of contact with waste, sites of waste scavenging, types of scavenged waste and common ailments among SWS. Statistical analysis was carried out using Student's t test, Chi square test, and Pearson's correlation co-efficient. The level of significance was $p \leq 0.05$. While the levels of Zn (2.91±0.92 µmol/dL) and Cu (2.20±0.47 µmol/dL) were significantly higher, the level of Fe (0.22±0.07 mg/L) was significantly lower in SWS compared to control (2.30±0.46; 1.73±0.47; 0.37±0.09) but Mn (11.00±0.20- SWS vs 9.00±0.04 nmol/L) was not significantly different in test and control groups. Frequency of health problems among SWS were backache (90%), headache (83%), joint pain (33%), and dizziness (20%). Results of the study suggest that solid waste scavenging is associated with various ailments as well as trace element alterations. The negative impacts of altered trace element metabolism on health are diverse.

Keywords: copper, iron, manganese, solid waste scavenger, zinc

1.0 INTRODUCTION

In the developing countries, high rate of unemployment and low educational status lead to various degree of poverty. This very serious socio-economic problem compels people to work anywhere, particularly in the informal sector for survival [1-4]. In many cities of Africa, Asia and Latin America, different categories of people survive by salvaging materials from the waste. These individuals, who are generally known as solid waste scavengers, recover the materials not only for their own consumption but also to sell for reuse or recycling. Workers and waste pickers handling solid waste throughout the world are prone to occupational health and accident risks related to the content of the materials they are handling, emissions from those materials, and the equipment being used [5-8]. Moreover, many scavengers specialize in collecting aluminum cans (soft drinks) and other metal containing wastes that can hinder the absorption of essential trace metals in the gut [7,9,10].

Essential trace elements are micronutrients required by humans in minute quantities to orchestrate a whole range of physiological functions. They also play a vital role in maintaining integrity of various metabolic processes occurring within living tissue [11,12]. Their bioavailability is affected by some toxic metals such as (lead and cadmium), many of which may be present in solid wastes and can interfere with the metabolism of required trace metals such as (zinc and manganese) thereby impeding the absorption of these elements and therefore derailing their functions [12,13]. The aim of the study is to investigate if alteration in serum trace element levels is one of the occupational hazards associated with solid waste scavenging.

2.0 MATERIALS AND METHODS

2.1 Ethical consideration

Ethical clearance was obtained from Ethical Committee of Ladoke Akintola University of Technology Teaching Hospital, Osogbo, Osun State. Informed consent was obtained from all participants. All data obtained were treated with complete anonymity.

2.2 Study design

The study is a cross-sectional comparative study.

2.3 Questionnaire Administration

Questionnaire was used to obtain information on occupation (degree of exposure; types of solid waste commonly encountered; sites of waste scavenging), socioeconomic conditions, health status or general health condition (injuries, complaints, and diseases), micronutrient supplementation, and life-styles (alcohol consumption and cigarette smoking).

2.5 Study Area

Recruitment of study participants took place at Sabo area in Olorunda local government, Osogbo, Osun State, Nigeria. The study area lies between latitude 7°52 north 4°35' east and longitude 7.867° north and 4.583° east (Nipost, 2012).

2.6 Sample Size and Sampling Technique

A sample size of 60 participants was used for the study. All participants were recruited through simple random sampling technique.

2.7 Study population

The participants consisted of 30 solid waste scavengers and 30 age-matched controls with age range of 15-50 years old. Each of the participants in solid waste scavenging group was expected to have spent a minimum exposure period of 1year in the occupation and 3-4 days a week. The age-matched control group had not been in waste-related business. Both groups were of similar socio-economic status, since this is capable of modulating micronutrient presentation even in the absence of pathology.

2.8 Exclusion criteria

The exclusion criteria for solid waste scavengers include, those on micronutrient supplementation, individuals who have not been in the occupation more than 1 year; those in other waste-related occupations but not solid waste scavenging.

2.9 Sample collection and trace element estimation

About five milliliters (mL) of venous blood sample was collected per subject from antecubital vein using approved vacutainers, which was centrifuged at 2500 rpm for 10 minutes to obtain serum for essential trace elements analysis. Samples were stored at -20ºC until analysis.

Appropriate precaution was taken to ensure that contamination of collected samples was minimized by avoiding sources of trace metal impurity from items such as rubber, cork, metal surfaces, skin and hair. In all instances, sample collection equipment and containers—including bottle and caps—were soaked in 1% nitric acid to ensure that trace metal contamination was minimized. Essential trace metals such as zinc, copper, manganese and iron were estimated in serum sample by Atomic Absorption Spectrophotometer using AAnalyst model 400.

2.10 Statistical analysis

The data obtained were subjected to statistical analysis and values were presented as mean ± Standard Deviation (SD). Statistical modelling used included Student's t test, Pearson's correlation co-efficient, and Pearson-Chi square test. All data were analysed using Statistical Package for Social Sciences (SPSS) version 23. $P<0.05$ was considered significant.

3.0 RESULTS

The results of the study are presented below. **Table 1** shows the mean±standard deviation of trace elements of solid waste scavengers and that of the control group. The serum levels of Zn and Cu of solid waste scavengers were significantly higher but the mean value of Fe was significantly lower compared with control ($p<0.05$). However, the mean value of manganese did not show any significant difference between the test and control subjects ($p>0.05$). Details of occupational information are provided in **Table 2**, while frequencies of some common indicators used for general health assessment of respondents are shown in **Table 3.**

In **Table 4,** there was no correlation between any of the quantified elements and the others ($p>0.05$). Using Chi square test of association, when the distribution of each of the elements was related to smoking status, no significant difference was observed ($p>0.05$). On the other hand, when the distribution of each of the elements was related to alcohol consumption, no significant difference was observed ($p>0.05$) for Cu, Fe, and Mn but Zn was significantly different at ($\chi2$= 7.252, p=0.027).

Table 1: Comparison Trace Element Parameters of Solid Waste Scavenger and control

Parameters	**Test subjects (n=30)**	**Control subjects (n=30)**	***P*-value**
Zinc (µmol/dL)	2.91±0.92	2.30±0.46	.01*
Copper (µmol/dL)	2.20±0.47	1.73±0.47	.01*
Iron (mg/L)	0.22±0.07	0.37±0.09	.01*
Manganese (nmol/L)	11.00±2.00	9.00±0.04	.70

Data presented as mean ± standard deviation; * Significant at p-value <0.05

Table 2: Occupational Information Of Respondents

Variable		Frequencies	Percentage (%)
Degree of contact			
Duration of work (years)			
	≤ 2	3	10
	>2	27	90
Duration of work per week (days)			
	≤ 5	3	10
	>5	27	90
Duration of work per day (hours)			
	≤ 6	9	30

	>6	21	70
<u>Site of waste collection</u>			
Dustbin	Yes	27	90
	No	3	10
Landfill	Yes	9	30
	No	21	70
Street	Yes	26	87
	No	4	13
<u>Types of waste collected</u>			
Electronics	Yes	16	53
	No	14	47
Metals	Yes	28	93
	No	2	7
Aluminium cans	Yes	23	76
	No	7	24

Table 3: General Health Assessment Of Respondents

Variables		Frequencies	Percentage (%)
Backache			
	Yes	27	90
	No	3	10
Headache			
	Yes	25	83
	No	5	17
Joint pain			
	Yes	10	33
	No	20	67
Dizziness			

	Yes	6	20
	No	24	80
Rashes			
	Yes	4	13
	No	26	87
Chronic disease			
	Yes	0	0
	No	30	100
Smoking of cigarette			
	Yes	18	62.07
	No	11	37.93
Alcohol consumption			
	Yes	4	13.7
	No	25	86.2
Micronutrient Supplementation			
	Yes	0	0
	No	30	100

Table 4: Table of Correlation of Fe, Zn, Mn, and Zn.

		Zn	Cu	Fe	Mn
Zn	r- value	1	0.118	0.058	-0.190
	p-value		0.536	0.761	0.315
Cu	r-value	0.118	1	-0.121	-0.171
	p-value	0.536		0.523	0.366
Fe	r-value	0.058	-0.121	1	0.240
	p-value	0.761	0.523		0.202
Mn	r-value	-0.190	-0.171	0.240	1
	p-value	0.315	0.366	0.202	

Data presented as Pearson's correlation coefficient (r)

4.0 Discussion

Contact with solid waste is a viable means of exposure to various chemical compounds as highlighted by Alam *et al.* [14]. Certain elements (both essential and toxic) have specifically been found in solid waste [15]. One may therefore speculate that the significantly higher levels of serum zinc of solid waste scavengers compared with control group may be associated with excessive exposure rather than any metabolic derailment. This could have been as a result of inhalation, ingestion or/and dermal contact of zinc and copper dust from waste materials handled or from dumpsites containing higher zinc and copper concentrations. It has been reported that there is increase in zinc concentration at the electronic waste dismantling sites and in dumpsites soil [16].

Interaction between elements is one of the characteristics of trace metals; this is a situation in which the presence of an element affects the absorption and bioavailability of another. It would have been expected that with significant increase in the level of zinc, that low level rather than significant higher copper level would have been observed in solid waste scavengers. Both Zn and Cu are known to interact; zinc ions have the ability to block copper absorption through formation of intestinal metallothionein that strongly binds copper [17]. But the results of the current study showed that the levels of both zinc and copper are elevated. This signifies that there was pronounced exposure to both elements from waste. According to Seniunaite and Vasarevicius [18] there is pronounced presence of zinc and copper as well as other elements in solid wastes. In consonance with the results of this study is the observation made by Chen *et al.* [19] in which elevated levels of zinc and copper were linked with electronic waste recycling. Although they reported an elevated level of manganese in their urine also, non-significant difference in the level of Mn was observed in the serum of solid waste scavengers recruited for the current study (when compared with control).

Various clinical conditions were reported in Metro Manila, one in four of the children recruited for a study on solid waste scavenging suffered from both chronic cough and wheezing, one in five of the children were afflicted with shortness of breath. And as many as seven children out of ten suffered from upper-respiratory ailments. These respiratory diseases included tuberculosis, pneumonia, asthma, and bronchitis. A similar study in Managua, Nicaragua, demonstrated that waste-picking children exhibited a decrease in lung function and wheezing due to a higher exposure to particulates [20]. Kennedy *et al.* [21] discovered that solid waste scavengers that specialized in bottle return process also manifested some of the symptoms as those found in Manila. Very many diseases have been linked with oxidative stress, included in that category (i.e. oxidative stress-related diseases), are a few of those mentioned above e.g. tuberculosis, pneumonia, asthma, and bronchitis. When either Zn or Cu occurs in the body at above physiologic range, it is capable of increasing free radical generation.

While various reasons have been offered as probable causes of low Fe status in different categories of human subjects, in the solid waste scavengers since poverty is a root cause of scavenging, the influence of malnutrition in the decreased Fe level cannot be discounted. Atinmo *et al.* [22] and Daboné *et al.* [23] identified that both poverty and malnutrition are the twin evils affecting a wide range of people in Africa. According to several sources, waste picking is portrayed as something done out of necessity, and the people doing it, are regarded as suffering from abject poverty. Aside this, heavy metals such as Cd and Pb are present in waste and they are capable of reducing absorption of essential bivalent compounds. It is commonly reported that the presence of bivalent heavy metals can cause interaction with iron.

The implications of low serum iron level are diverse. While diseases such as typhoid fever, tuberculosis, dysentery, poliomyelitis, malaria, and various skin disorders that have been identified in Manila in informal recycling communities reported by Medina [24] could not have resulted from low iron level but the low hemoglobin reported by Wachukwu *et al.* [25] might have occurred from low Fe status found in solid waste scavengers. Although it is important to emphasise that low Hb has not only non-hemolytic causes but hemolytic ones as well

Moreover, another possible cause of low iron levels in scavengers (when compared with control) can be attributed to high toxic metal presence while this may simply be speculative since heavy metal content of the serum was not included in this study, the possible interaction between Fe and elevated zinc or copper levels cannot be ignored. The fact that Sarka *et al.* [26] identified high levels of lead in the blood of recyclers working in landfills, makes Pb also a candidate for a cause of low iron level. The presence of lead has been confirmed in various biologic specimens of individuals linked with solid waste processing, for example lead was discovered in higher concentration in the breast milk of women neighbouring landfills of recycler communities [26]. Although the significant decrease in Fe level may be as a result of elevated levels of other heavy metals, lack of correlation between Fe and both zinc and copper was observed which makes this unlikely.

It has been identified that the incidence of acute diarrhea was 10 times greater in informal recyclers than in the general population. In stool samples taken from children working in Manila, it was confirmed that 98% had parasites, either *Trichuristrichiura*, *Ascaris lumbricoides*, or both. A report from World Health Organization (WHO) indicated that most often diarrhea and parasitic infections are associated with solid waste scavenging. Cholera and an acute intestinal infection among many infectious states are additional malaise of this occupation. Diarrhea, vomiting, and parasitic infections that give rise to intestinal infections are conditions capable of reducing nutrient availability in an individual even with adequate nutritional intake. Any or all of these conditions have been identified as being capable of causing iron deficiency anemia. When the economic status of solid waste scavengers are then taken into consideration alongside likelihood of various intestinal diseases, the cause of low level of Fe may thus be identified.

The backache reported to be a common ailments among 90% of the solid waste scavengers, could be as a result of repeatedly moving and lifting heavy objects, such as carts and bags filled with solid waste. Other ailments identified in the solid waste scavengers (such as backache, headache, joint pain, dizziness) may be linked to stress or rigour associated with this occupation, although metabolic derangement (resulting in oxidative stress) may not be over-looked. While only13.7% identified alcohol consumption as a lifestyle choice, still there was a significant association between serum zinc levels of those consuming alcohol compared to those that are not alcohol consumers. A relationship between zinc level (serum and hepatic) and alcohol consumption is well described. The result of the present study is contrary to earlier reports in which alcohol consumption co-existed with zinc depletion.

Conclusion

Solid waste scavengers that picked items such as metals, electronics and aluminium cans from dustbins, landfills and streets presented with significant increase in levels of zinc, copper and iron when compared with control group. The significant alterations could not be related to metal interaction due to lack of correlation among the four quantified elements. In addition, high frequency of different ailments such as headache, backache, joint pain, dizziness, rashes were observed in scavengers

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