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Original Article

Possible Role of Plasma Ceruloplasmin and Erythrocyte Sedimentation Rate in Assessing Compliance with Occupational Hygiene and Safety Practices in Waste Management Workers

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ABSTRACT

Objectives: Work-related health and safety risks are common among waste management workers (WMWs). This study investigated the level of compliance with safety measures in relation to levels of inflammatory markers among WMWs in Sagamu, South-West Nigeria. **Materials and Methods:** WMWs comprising 30 cart pushers (CPs) and 50 truck users (TUs) were recruited alongside 45 people from the normal population as control. Data on health complaints were obtained from questionnaire surveys. Inflammation was assessed by measuring plasma ceruloplasmin (Cp), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and albumin. **Results:** WMWs exhibited a significantly higher prevalence of respiratory and gastrointestinal symptoms and poor compliance with health and safety measures. Significant ($P < 0.001$) differences were observed in the use of masks, hand gloves, protective clothing, and footwear between TUs and CPs. ESR, Cp, and CRP increased significantly ($P < 0.001$) by 145, 28.7, and 42.5% in TUs and by 164, 50.5, and 74.3% in CPs, respectively, relative to control. Negative correlation was observed between use of mask ($r = -0.225$, $P < 0.01$), use of gloves ($r = -0.184$, $P < 0.05$), and Cp and between ESR and washing of hands with soap ($r = -0.185$, $P < 0.05$). The use of goggles ($r = +0.285$, $P < 0.001$), washing of hands with soap ($r = +0.203$; $P < 0.01$), use of masks ($r = +0.317$, $P < 0.001$), and use of gloves correlated positively in WMWs. **Conclusions:** A higher prevalence of work-related symptoms and elevated inflammatory markers in WMWs was related to poor compliance with safety measures. ESR and Cp may be useful predictors of occupational hygiene and compliance with safety measures among Nigerian WMWs.

Key words: Compliance, inflammatory markers, municipal solid wastes, occupational exposure, safety assessment

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INTRODUCTION

Effective management of waste is important for both aesthetic environmental and public health reasons.[1] It has contributed immensely to human health by reducing the risk of several diseases like typhoid fever and cholera.[2] Collection of waste varies from informal manual gathering to semiautomated systems and involves the removal of waste

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materials from households, typically in urban and suburban areas, to either the point of recycling or final disposal.[2] Several studies have reported the existence of work-related health and safety risks for waste collectors such as exposure to elevated concentrations of biological aerosols,[3-7] respiratory and gastrointestinal complaints,[2,8-12] infectious diseases like hepatitis A, B, and C, HIV, and syphilis.[13-15]

Occupational health and safety have become increasingly regulated to minimize work-related risks in the past two decades.[16] This has affected the *modus operandi* involved in the collection of waste in most high-income countries in various ways including the use of vehicles with low loading heights and easy-to-lift plastic containers or bags, organization of formal training for workers, the use of gloves when loading, sorting of waste at materials recovery facilities with dust suppression, conveyance enclosure, ventilation-controlled work environments, and the use of personal respiratory protection equipment by waste workers if working spaces do not meet air standards set for occupational safety and health.[16]

Several studies have reported the health and safety risks associated with exposure to solid waste especially in the developing countries where exposure is the greatest and the level of protection is poor.[2,16-19] In Nigeria, there is a rise in the number of people involved in disposal of solid waste as a means of livelihood because of the recently introduced Private Partnership Scheme (PPS) in waste management by various state governments and predominantly driven by an informal sector of the nation's economy. The informal waste management sector, therefore, provides one of the best income-generation opportunities for many unskilled laborers and utilizes low-scale, inexpensive technologies.

Waste management workers (WMWs) face elevated safety and health risks constantly as a result of unsafe handling of waste materials and lack of protective equipment.[20] In most developing countries, they may not be adequately compensated for such risks because of limited access to health-care facilities. It is important, therefore, that the health of the workers is preserved or protected as this is their greatest asset and a precondition for sustainable generation of income. Studies have demonstrated that waste collectors in Nigeria suffer from health consequences of their occupation.[19,21-24] These waste workers are so economically tied to the occupation in a bid to make a living that they are often unaware of the dangers and occupational hazards they face on a daily basis.[16,25] Little attention has been paid to compliance with health and safety measures among waste workers in most developing countries despite the fact that knowledge about the level of compliance is a necessary requirement and a vital starting point for health and safety campaigns. Insight into the effects of noncompliance and underlying determinants is known to influence the design of intervention[26] and epidemiologic studies.[27] The use of personal protective equipment (PPE) such as appropriate footwear and gloves and measures of good personal hygiene also limit the chances of coming into contact with infectious agents. Data on the compliance of Nigerian WMWs with safety measures and its attendant effects on their health status are sparse. In the present study, we investigated the level of compliance of WMWs of Sagamu, South-West Nigeria, with safety measures and related this to the levels of systemic markers of inflammation. This correlation was intended to establish the possible relevance of these inflammatory markers as bioindicators of compliance with safety regulations among these waste workers.

MATERIALS AND METHODS

Subjects and work conditions

Eighty male municipal solid waste (MSW) management workers (median age: 37 years) comprising 30 cart pushers (CPs) and 50 truck users (TUs) participated in the study. Forty-five (45) people from the normal population were recruited alongside and served as control. The subjects were selected by purposive sampling from three private waste management companies in Sagamu, southwest of Nigeria, in line with previous studies.[19,28-30] Both categories of waste workers function under private facilities with informal operations, work eight hours daily and for six days every week. The TUs received informal training before commencement of work, whereas the CPs had no such training. There was no preemployment medical screening or immunization and periodic medical checkup for both categories of waste workers. Provision of subsidized medical care was available for sick TUs. The CPs subjects were self-employed and did not have access to any subsidized medical care whenever such was needed.

Exclusion criteria for the enrolment of workers included the presence of conditions (such as diabetes, asthma, hypertension, malaria) with an underlying inflammatory mechanism and the use of drugs which interfere with inflammatory response or process.[31-34] Individuals with any visible wound or lesion which may predispose to infection and/or inflammation were also excluded. The medical ethics committee of the Olabisi Onabanjo University Teaching Hospital (OOUTH) and the Obafemi Awolowo College of Health Sciences (OACHS), Olabisi Onabanjo University, approved the study (ethical approval number: OOUTH/DA.226/T/2). The participants gave informed written consent in accordance with the amended Helsinki Declaration of 1964.[35]

Five (5) ml of blood sample was collected from the antecubital vein of all the subjects at the end of the work week after an overnight (12-14 hours) fast for analysis. Investigation was done simultaneously for control and WMWs to eliminate the confounding effect of environmental variation on health response.

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Collection of respiratory, general health, and work practice data

Data on work-related health complaints and work practice were obtained as described in our previous study.[30] Briefly, the subjects were interviewed and asked to complete a questionnaire requesting information about socio-demographic characteristics, habits, work practice, and duration of work as well as self-reported work-related respiratory and gastrointestinal symptoms experienced in the last three months prior to the interview or commencement of study. Signs and symptoms presented by an individual at least once in the last week and twice in the previous three months were recorded. Respiratory symptoms were ascertained from questionnaire responses, and answer options to questions on gastrointestinal symptoms and other health complaints were categorized as either "NO" when there were "no symptoms" and "symptoms present some times per year" or "YES" when "symptoms were present some times per month or more frequent".

Evaluation of systemic inflammation

This was carried out by measuring blood levels of ceruloplasmin (Cp), C-reactive protein (CRP), albumin, as well as erythrocyte sedimentation rate (ESR). Cp was measured from its oxidase activity using *o*-dianisidine dihydrochloride.[36] CRP and albumin concentrations were determined according to the methods of Eda *et al.*[37] and Doumas *et al.*,[38] respectively, whereas ESR was measured according to the method described by Westergren.[39]

Statistical analysis

Results are presented as mean ± standard deviation for continuous variables and percentage (%) for categorical variables. Differences between groups were determined by one-way analysis of variance (ANOVA) using the Package for Social Sciences (SPSS) software for Windows version 16.0. Posthoc test was performed for intergroup comparisons using the least significant difference (LSD) and Pearson's correlation coefficient. Categorical data were compared by Fisher's exact test and χ^2-test. Risk estimate was performed using odds ratio (OR). The statistical significance was set at $P < 0.05$.[40]

RESULTS

Subject characteristics and biophysical data

The demographic details of age, level of education, smoking, use of alcohol, and food habits of the three groups of subjects are depicted in Table 1. Majority of the young waste workers (between 20 and 29 years) were CPs (73.3%), whereas only 36.1% of TUs were within this age range. There were older waste workers between 30 and 39 and 40 and 49 years of age in the TUs category (33.9 and 23.3%, respectively). Surprisingly, 10.0% of CPs and 6.7% of TUs were between 50 and 59 years of age. Most CPs (63.3%) had no formal education, whereas only 14.0% of TUs were in this category. In addition, 46.0, 32.0, and 6.7% of TUs had primary, secondary, and tertiary levels of education, respectively. All waste workers including control were comparable with respect to smoking, use of alcohol, and food habits.

Personal and occupational hygiene of solid waste workers

Table 2 summarizes personal and occupational hygiene of the waste workers. Significant ($P < 0.001$) differences were recorded in washing of hands with water and soap before eating at work and regular nail cutting of hand and foot between TUs and CPs.

Work-related health problems among waste workers

The prevalence of respiratory symptoms and other general work-related health problems are presented in Tables 3 and 4, respectively. Common upper respiratory symptoms in MSW management workers were frequent sneezing, and running, stuffy, or itching nose. Chest discomfort or pain, cough with phlegm, and dry cough were the common lower respiratory symptoms found in the solid waste workers [Table 3]. General health complaints such as diarrhea, stomach trouble, headache, irritation of eyes, nausea, abrasions, cuts and pricks on the body surface, as well as musculoskeletal complaints (pain in the shoulder, knee, neck, and lower back) were significantly more frequent in CPs and TUs waste workers when compared with control subjects [Table 4].

Table 1: Socio-demographic characteristics of subjects

Characteristics	CPs (*n*=30)		TUs (*n*=50)		Control (*n*=45)	
	n	%	*n*	%	*n*	%
Age (years)						
20-29	22	73.3	18	36.1	12	26.6
30-39	2	6.7	17	33.9	22	49.0
40-49	3	10.0	12	23.3	9	20.0
50-59	3	10.0	3	6.7	2	4.4
Education						
No formal education	19	63.3	7	14.0	5	11.0
Primary	8	26.7	23	46.0	20	44.0
Secondary	2	6.7	16	32.0	18	40.0
Tertiary	1	3.3	4	8.0	2	5.0
Smokers	5	16.7	8	16.0	8	17.8
Alcohol use	8	26.7	13	26.0	11	24.4
Food habit						
Vegetarian	0	0	0	0	0	0
Mixed	30	100	50	100	45	100

n = Number of subjects, CPs = Cart-pushers, TUs = Truck users

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Table 2: Personal and occupational hygiene of solid waste workers

Occupational/personal hygiene	CPs (n=30)	TUs (n=50)	OR (95% CI)	χ^2 value	P value
Eat at work	77.77	65.85	0.551 (0.152-1.992)	0.839	0.540
Hand washing with water	48.78[a]	55.56	0.366 (0.245-0.541)	17.916	0.000
Hand washing with soap	27.77[a]	43.59	1.470 (1.320-1.780)	13.233	0.000
Bath before work	38.89	39.02	0.640 (0.209-1.955)	0.617	0.308
Bath after work	56.57	73.17	1.147 (0.097-13.522)	13.009	0.672
Regular nail cutting	72.22[a]	51.22	0.062 (0.01-0.508)	10.195	0.001
Smoking at work	2.1	2.2	1.084 (1.190-6.073)	1.235	0.191

Results are expressed in percentages of individuals; n = Number of subjects, TUs = Truck users, CPs = Cart pushers, OR = Odds ratio, CI = Confidence interval. $P \leq 0.05$ represents significance. [a]Significantly different from TUs

Table 3: Prevalence of respiratory symptoms in solid waste workers

Symptoms	CPs (n=30)	TUs (n=50)	Control (n=45)	P value
Frequent sneezing	22.6[a]	16.4[a]	9.7	0.007
Dry cough	39.6[a]	35.3[a]	13.4	0.000
Itching/irritation (nose)	38.8[a]	27.0	23.9	0.022
Cough with phlegm	31.6[a]	15.5	17.7	0.040
Chest discomfort or pain	23.1[a]	17.9[a]	14.1	0.000
Running/stuffy nose	31.9[a]	19.8	19.5	0.024
Breathless on exertion	55.5[a]	53.4[a]	19.0	0.000

Results are expressed in percentages of individuals. CPs = Cart pushers, TUs = Truck users, P values are calculated versus the control group with Fisher's exact test, two sided, [a]Significantly different from control

Table 4: Prevalence of general work-related health complaints in waste workers

Symptoms	CPs (n=30)	TUs (n=50)	Control (n=45)	P value
Diarrhea	37.2[a]	17.4[a]	10.0	0.037
Irritation of eyes	46.1[a]	40.1[a]	19.0	0.004
Nausea	32.2[a]	31.5[a]	12.0	0.004
Headache	39.8[a]	35.9[a]	18.00	0.001
Stomach trouble	39.4[a]	35.8[a]	16.0	0.008
Cuts/pricks/needle prick	29.8[a]	22.2[a]	9.1	0.000
Abrasions	47.8[a]	34.9[a]	10.9	0.000
Shoulder pain	58.6[a]	49.7[a]	12.0	0.009
Knee pain	38.7[a]	29.4[a]	11.0	0.009
Neck pain	23.6[a]	20.1[a]	13.0	0.025
Low back pain	67.7[a]	64.5[a]	21.0	0.000

Results are expressed in percentages of individuals. CPs = Cart pushers, TUs = Truck users. P values are calculated versus the control group with Fisher's exact test, two sided. [a]Significantly different from control

Systemic inflammation

Table 5 summarizes the levels of ESR, Cp, CRP, and albumin of MSW workers and control. The MSW workers exhibited significantly ($P < 0.001$) elevated Cp and CRP together with a significantly ($P < 0.001$) lower level of albumin when compared with control. ESR, Cp, and CRP increased significantly ($P < 0.001$) by 145, 28.7, and 42.5%, respectively, whereas albumin decreased by 8.1% in TUs when compared with control. Similarly, the ESR, Cp, and CRP of CPs increased by 164, 50.5, 74.3%, respectively, whereas albumin decreased by 12.1% when compared with the control.

Level of compliance of waste workers to safety regulations

Compliance of waste workers with occupational hygiene and safety regulations is presented in Table 6. Although the compliance of TUs with health and safety measures was far below average, the compliance of waste workers in the CPs category was extremely poor. The CPs subjects seldom used protective masks and gloves, whereas TUs used PPE occasionally when handling wastes.

Correlation analysis of inflammatory markers with parameters of safety measures

The correlation coefficient between systemic inflammatory markers and indices of safety regulations is presented in Table 7. A negative correlation was observed between Cp ($r = -0.225$; $P < 0.01$), ESR ($r = -0.212$; $P < 0.05$), and the use of masks in the waste workers. Also, a negative correlation was observed between Cp ($r = -0.184$; $P < 0.05$) and the use of hand gloves as well as between ESR ($r = -0.185$; $P < 0.05$), CRP ($r = -0.175$; $P > 0.05$), and washing of hands with soap and water before eating at work. A significant correlation also existed between the use of goggles ($r = +0.285$; $P < 0.01$), washing of hands with water before eating at work ($r = +0.202$; $P < 0.01$), washing of hands with soap and water before eating at work ($r = +0.201$, $P < 0.01$), use of hand gloves ($r = +0.317$, $P < 0.01$), and use of masks. Similarly, there was a significant correlation between washing of hands with water before eating and washing of hands with soap and water before eating at work ($r = +0.564$, $P < 0.001$) as well as between ESR ($r = +0.451$, $P < 0.001$), Cp ($r = +0.343$, $P < 0.001$), and CRP.

DISCUSSION

Growth in the generation of MSW has provided a remarkable impetus to the growth of the waste management industry in Nigeria. The current waste management practices of the country have had significant implications of health

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Table 5: Inflammatory marker levels of solid waste workers and control subjects

Parameters	CPs (n=30)	TUs (n=50)	Control (n=45)	F value	P value
ESR (mm/hr)	29±10[b] (164)	27±11[b] (145%)	11±9	5.914	0.000
ALB (g/L)	33.0±3.0[b] (–12.1)	34.0±3.0[b] (–8.1)	37.0±4.0	8.826	0.000
Cp (U/l)	162.8±45.9[bc] (50.5%)	139.5±51.6[b] (28.7)	108.5±33.7	13.933	0.000
CRP (g/L)	19.7±7.8[bc] (74.3%)	16.1±8.3[b] (42.5%)	11.3±5.2	8.964	0.000

Values are expressed as mean±standard deviation (SD). Values in parenthesis represent % change relative to control. n = Number of subjects, Cp = Ceruloplasmin oxidase activity, CRP = C-reactive protein, ALB = Albumin, ESR = Erythrocyte sedimentation rate, TUs = Truck users, CPs = Cart pushers. [b]P<0.001 when compared with control; [c]P<0.05 when compared with TUs

Table 6: Compliance of solid waste worker with occupational safety measures

Safety measures	% Compliance		OR (95% CI)	χ^2 value	P value
	CPs (n=30)	TUs (n=50)			
Wearing of goggles	2.6	2.8	1.094 (1.190-10.073)	0.006	0.709
Wearing of mask	0[a]	54.2	1.600 (1.370-1.857)	36.805	0.000
Wearing of gloves	0.9[a]	48.6	1.470 (1.320-1.780)	30.309	0.000
Protective clothing	0.9[a]	54.2	8.036 (2.973-21.772)	21.168	0.000
Protective shoes	0[a]	34.5	6.456 (4.342-8.645)	13.009	0.000
Smoking at work	2.1	2.2	1.084 (1.190-6.073)	1.235	0.191

Results are expressed in percentages of individuals; n = Number of subjects, TUs = Truck users, CPs = Cart pushers, OR = Odds ratio, CI = Confidence interval.
[a]Significantly different from TUs

Table 7: Coefficient of correlation between inflammatory indices and parameters of safety measures (n=80)

Parameter/safety measures	Goggle	Mask	Hand eating	Soap	Hand gloves	Overall cloth	ESR	ALB	Cp	CRP
Goggle	1	0.285[c]	0.067	0.039	0.013	–0.102	–0.175	0.109	–0.101	–0.089
Mask	0.285[b]	1	0.202[d]	0.201[d]	0.317[b]	0.113	–0.212[c]	0.024	–0.225[c]	–0.072
Hand eating	0.067	0.202[d]	1	0.564[b]	0.223[d]	0.052	–0.169	–0.050	–0.093	–0.079
Soap	0.039	0.201[d]	0.564[b]	1	0.223[d]	0.132	–0.185[c]	0.030	–0.095	–0.175
Hand gloves	0.013	0.317[b]	0.223[d]	0.203[d]	1	0.072	0.058	0.034	–0.184[c]	0.119
Overall cloth	–0.102	0.113	0.052	0.132	0.072	1	–0.055	–0.007	–0.081	0.005
ESR	–0.175	–0.212[d]	–0.169	–0.185[c]	–0.058	–0.055	1	–0.129	0.278[d]	0.451[b]
ALB	0.109	0.024	–0.050	0.030	0.034	0.007	–0.129	1	0.068	–0.138
Cp	–0.101	–0.225[d]	–0.093	–0.095	–0.184[c]	–0.081	0.278[d]	0.068	1	0.343[b]
CRP	–0.089	–0.072	0.079	–0.175	–0.119	0.005	0.451[b]	–0.138	0.343[b]	1

Goggle: Use of goggle; Mask: Use of face mask; Hand eating: Washes hands with water only before eating at work; Soap: Washes hands with soap and water before eating at work; Hand gloves: Use of hand gloves; Overall cloth: Wears overall protective clothing; ESR = Erythrocyte sedimentation rate, ALB = Albumin, Cp = Ceruloplasmin, CRP = C-reactive protein; [b]P<0.001; [c]P<0.05; [d]P<0.01

and safety risks in addition to the overt environmental contamination that is generally experienced by urban dwellers.[41] The WMWs are the most vulnerable to waste hazards because of their direct involvement in the disposal of waste, and evidence abounds on work-related health and safety risks among these individuals.[2,10,12,16,42] We identified some important systemic inflammatory markers as useful biomonitors of health and safety of WMWs of Ogun State, South-West Nigeria, in our recent study.[19] In the present investigation, we evaluated the possibility of using these systemic inflammatory indices as predictors and bioindicators of compliance of WMWs with safety practices with particular reference to those in the CPs and TUs categories.

Demographic data revealed that the WMWs in the CPs category were predominantly without any form of formal education. The few individuals (27%) in this group with formal education only had primary education. The waste workers in the TUs category, on the other hand, had a better level of education, with 45 and 35% of these individuals possessing primary and secondary levels of education, respectively. Because of the prevailing high rate of unemployment in Nigeria, which as a matter of fact is assuming an alarming rate in recent times, it is not surprising that a few individuals (3% of CPs and 8% of TUs) with a tertiary level of education are involved in this menial job of waste collection and disposal to make two ends meet. With the present staggering level of poverty coupled with a worrisome rate of unemployment in Nigeria,[43] it is also not surprising that all the WMWs in the CPs category were self-employed and as a result did not have any opportunity to go through any pre-employment training.

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The low educational status, poor remuneration, and absence of pre-employment training obviously would have accounted for the poor level of awareness of inherent health risks and hazards associated with handling of waste as well as the extremely poor compliance with health and safety regulations among these individuals. Many of them also attributed their failure to adhere to safety procedures to general discomfort occasioned by the use of PPE, and outright negligence and carelessness on their part. Similar observations of poor compliance with safety measures have also been reported among landfill workers and ragpickers in India, Quebec, and Nepal.[10,44,45]

Furthermore, the outright lack of formal education among the CPs (61.4%) may be an important factor for the absence of training and the extremely low level of health risk awareness. These factors may constitute significant impediments in conducting formal training and health/safety education for these waste workers. This informed the recommendation by Memishi,[46] who noted that many recycling workers in the United States were illiterates and suggested that videotapes, rather than printed materials, should be used for their training. There is no doubt that training is an essential and indispensable aspect of any vocation. Becker and Morawetz[47] evaluated the influence of the training program by the International Chemical Workers Union Council for hazardous waste workers on the attitude and post-training activities of trained union workers, and observed that workers were more willing to attempt to change worksite conditions following training, and that their efficacy at making changes was substantially greater than before they were trained. Training for WMWs entails proper techniques of lifting and carrying, constituents of MSW and potential hazards of exposure to aerosol contaminants, techniques for inclement of the weather, and the use of PPE. The significant acquisition of various levels of education among the TUs category of waste workers in this study should be an important factor in their high awareness (64.2%) of health risks as well as obtaining formal/informal training before commencement of the job. Both categories of workers did not enjoy any privilege of pre-employment medical screening and immunization and neither was there any periodical medical checkup. Although basic PPE like gloves and face masks were provided for the TUs at the commencement of the work, they were, however, rarely replaced when worn out. Some waste workers, on the other hand, were either unaware or nonchalant about the risks associated with the handling of waste and did not undertake protective measures, whereas some of the waste workers purchased some of the PPE they could afford by themselves.

Apart from the use of eye goggles where compliance was comparable between CPs and TUs, the latter demonstrated a significantly higher compliance with the use of PPE in this study. The significantly higher compliance of TUs with occupational hygiene and safety regulations may be attributable to their better educational status and the training they had received before commencement of work. Although the assumption exists that the use of protective equipment by solid waste workers reduces the associated negative outcomes of health,[48] the available literature, however, yields mixed reports as to whether there is a significant protective effect with the use of PPE.[49,50] Our present study seems to uphold this assumption, as our results revealed a higher prevalence of respiratory symptoms and other general work-related health problems among CPs when compared with the TUs counterparts.

Furthermore, a significant correlation was observed between the use of goggles ($r = +0.285$; $P < 0.01$), washing of hands with water only before eating at work ($r = +0.202$; $P < 0.01$), washing hands with soap and water before eating at work ($r = +0.201$, $P < 0.01$), use of hand gloves ($r = +0.317$, $P < 0.01$), and use of masks. Also, a significant association existed between washing hands with water before eating at work and washing hands with soap and water before eating at work ($r = 0.564$, $P < 0.001$). This suggests that workers who use one piece of PPE have a greater tendency to use others and to either wear protective equipment always or never. Malkin *et al*. reported a similar observation in incinerator workers.[51] Similarly, the use of hearing protection has been reported to decrease hearing difficulty and ringing in the ears significantly of sanitation employees in New York city, without any protective effect on work-related respiratory and dermatologic symptoms with the use of protective masks.[50]

In line with our previous report of a marked increase in systemic biomarkers of inflammation among WMWs,[19] the significantly elevated inflammatory markers observed in this study correlated positively with one another and appear causally related with the poor level of compliance of these WMWs with safety practices. We observed that use of masks by waste workers correlated significantly negatively with Cp ($r = -0.225$; $P < 0.01$) and ESR ($r = -0.212$; $P < 0.05$). A significant negative correlation was also observed between the use of hand gloves and Cp ($r = -0.184$; $P < 0.05$), whereas washing of hand with soap and water before eating among waste workers at work correlated with ESR ($r = -0.185$; $P < 0.05$) and CRP ($r = -0.175$; $P > 0.05$). In addition, data from this study revealed that ESR has an association with nonobservance of occupational hygiene, whereas Cp is associated with noncompliance with the use of mask and gloves. Our result therefore suggests that Cp may be useful in evaluating compliance with the use of PPE like masks and gloves, whereas ESR and CRP may be useful for assessing compliance with occupational hygiene among the waste workers. Associations between the use of goggles, washing of hands with water before eating at work, washing of hands with soap and water before eating at work, use of hand gloves, and use of masks revealed the likelihood that

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workers who use masks may also comply with the use of other safety measures.

In summary, we reiterate the relationship between occupational exposure to MSW without adequate protection and elevated levels of inflammatory markers while providing additional evidence to demonstrate a significant correlation between levels of ESR and Cp and occupational hygiene and safety practices among WMWs in this study. We therefore propose that measuring the plasma level of these inflammatory markers (ESR and Cp) may provide a relatively quick and cheap method of assessing the level of compliance of WMWs with health and safety guidelines, while putting appropriate formal directives in place to promote and ensure adherence to safety measures and proper practices of waste management.

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