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Is There an Association between the Type of Activities and Respiratory Disorders among e-Waste Workers? Case of Two Major Cities in West Africa

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Abstract

Background: Several studies have demonstrated that e-waste workers had a risk to develop the respiratory disorders but this was not specifically differentiated according to the type of the e-waste activities. The main aim of this study was to evaluate if the risk to develop respiratory disorders was different according to the type of activities carried out by the e-waste workers. **Methods:** A cross sectional study was conducted in Abidjan and Cotonou, two big cities in West Africa. The participants were randomly selected based on the list of e-waste workers provided by the census of different sites of e-waste. The spirometry was performed on all the study participants to assess whether they had respiratory disorders. A regression logistic model was performed to estimate the risk of developing respiratory disorders according to the type of activities carried out by the e-waste workers. **Results:** In total 308 e-waste workers including 149 at Abidjan and 159 at Cotonou were interviewed. Participants of this study ranged in age from 14 years to 69 years and the mean age was 33.71 ± 10.96. The main activities carried out by the study participants were respectively repairing (44.8%), buying or selling (40.3%), dismantling (31.8%). The prevalence of respiratory disorders was 20.1%. The multivariate analysis had not found a significant association between the type of activities and the presence of respiratory disorders. **Conclusion:** The effect of exposure to e-waste on respiratory health of workers was not different according to the type of activities. So, any policy that aims to reduce the risk of exposure on respiratory health must take into account all the e-waste workers regardless of

the type of activities they perform in this sector.

Keywords

e-Waste, Activities, Respiratory Disorders, West Africa

1. Introduction

Most of the e-waste collected from Europe is shifted to Asian and African countries for dismantling and recycling [1]. According to the World Bank, 80% of e-waste is illegally shipped to developing countries, many of them in Africa [2]. The consequence in Africa is that many e-waste dumps have sprung up and unprotected workers are trying to extract metals from this equipment [3]. These workers expose themselves to serious health problems and several studies showed that e-waste is becoming a threat to human health [4] [5] [6] [7]. Indeed handling of e-waste can lead to the serious health problem [8]-[14]. Change in thyroid function, changes in cellular expression and function, adverse neonatal outcomes, changes in temperament and behavior, and decreased lung function are plausible outcome associated with exposure to e-waste [8] [15]. We know that e-waste activities are categorized in the main activities such as dealing, sorting, dismantling and burning [15]. But these different types of activities have not been taken into account in the estimation of the respiratory health risks related to work in the e-waste sector. So the aim of this study was to determine whether there is an association between the type of activities carried out by the e-workers and the presence of respiratory disorders among the e-waste workers from Abidjan in Ivory Coast and from Cotonou in Benin.

2. Materials and Methods

2.1. Study Site

This study took place in two major cities in West Africa. The concerned cities were Cotonou in republic of Benin and Abidjan in republic of Côte d'Ivoire. The particularity of these cities concerns their geographical position. They are located by the sea. So, the situation of e-waste in these cities represents a major problem for all the ecosystem.

For the sampling of this study, all e-waste dumps have been identified and the GPS coordinates have been taken. **Figure 1** showed the mapping of these dumps.

2.2. Study Population

The study was carried out in 2019 on the e-waste workers recruited in informal sector in each zone of study site. Among the e-waste workers that are exposed to air pollution related to e-waste manipulation, three major categories are distinguished. These are collectors, recyclers and repairers [16] [17]. The main activities

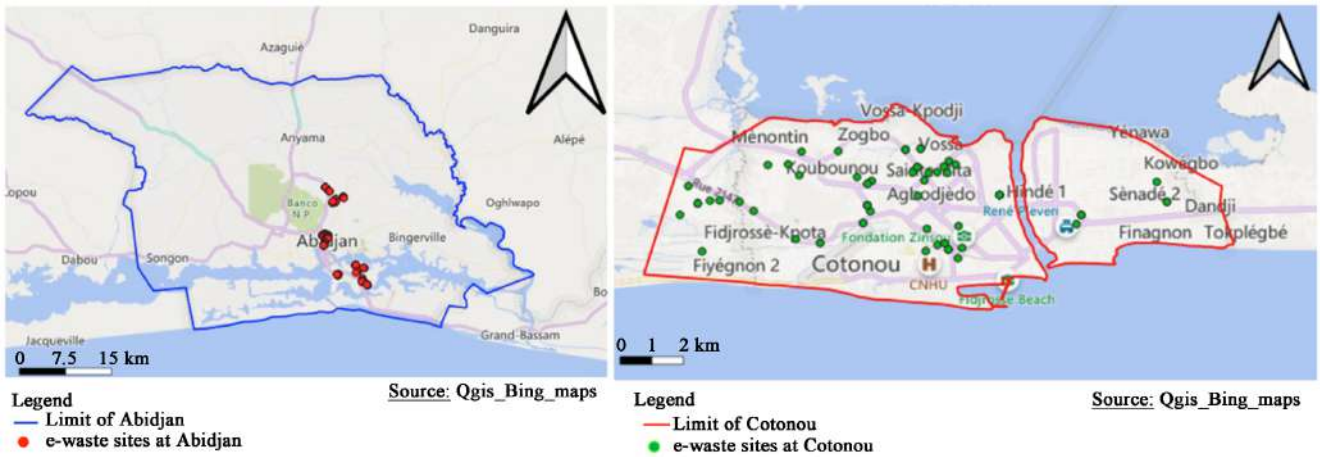

Figure 1. Map of different e-waste sites in Abidjan (Côte d'Ivoire) and Cotonou (Benin).

of collectors are collection or unloading of electronic waste and sorting or selling of products from waste electronic waste. During their activities, the recyclers practice dismantling of e-waste, removal of the coating of electronic wires, burning of electronic wires o, collection of wires after burning and the melting of lead-acid batteries. Dismantling of e-waste, removal of coating from electronic wires, burning of electronic wires, collection of wires after burning and melting of lead-acid batteries are the main activities of the repairers.

2.3. Type of Study and Sampling

We conducted a cross-sectional study from September to November in 2019. For each zone of the study site, the sample size was determined using the formula of Schwartz with the following assumptions:

- the prevalence of respiratory disorders among e-waste workers is 24.7% [18].
- Risk $\alpha = 5\%$ and precision $i = 7\%$.

With these assumptions the minimal sample size was 146. To prevent the non-responses, we increased the sample size by 10%. So, we expected approximately 161 e-waste workers at each zone. To prepare this sampling, we conducted a census of the e-waste workers at each zone. This allowed us to know that there are approximatively 35% of e-waste collectors, 40% of e-waste recyclers and 25% of repairers. The sample size was distributed proportionally to the weight of each category.

The selection of participants was done randomly based on the list of e-waste workers provided by the census. The selected participant was included in the study when his/her consent was obtained before starting the interview. If the consent was not given, we selected another participant.

2.4. Data Collection

The questionnaire for the data collection was developed in three parts. The first part concerned some demographics information. The second part concerned the main activities carried out by the workers in the e-waste sector and some infor-

mation about their history.

The last part was dedicated to the respiratory health outcomes. In this part, the participants were interviewed to collect some reported respiratory symptoms. Then spirometry was performed on all the study participants to assess whether they had respiratory disorders.

In accordance with the principles of the Eco-Health approach, an ethical approval was obtained in each country for this research.

2.5. Statistical Analysis

Descriptive data were expressed as means and standard deviation, frequency, and percentages where appropriate. The dependent variable was respiratory disorders detected by spirometry. The participant was considered with respiratory disorders when the result of his spirometry is declared anormal. We performed a bivariate analysis using Chi^2 test or Fisher's test between the variable of respiratory disorders and each of the different variable to detect a probable association statistically significant.

Then, we coded the dependent variable as 0 if the result of spirometry was normal and as 1 the result of spirometry was anormal. The main independent variables were X1: repairing, X2: buying or selling, X3: dismantling and X4: collection or discharge. Analyzes were conducted to see the association between Xi (i = 1, 2, 3, 4) and the dependent variable was statistically significant. First, we performed logistic regression models (model 1, model 2, model 3, model 4) respectively with X1, X2, X3 and X4. In the second part we performed a logistic regression model (model 5) with all the variables that represented the different type of activities. All the models were adjusted using the following variables: age category, education, seniority in the e-waste activity, wearing protective equipment, place of living, family asthma history and cigarette smoking. Statistical analyzes were performed using Stata and the association was considered significant in p-value lower than 0.05.

3. Results

3.1. Category of Study Participants

Table 1 shows the distribution of e-waste workers by activity category. In total 308 e-waste workers participated to this study. 159 for Benin and 149 for Côte d'Ivoire. In each country approximately 35% of participants were collectors, 42%

Table 1. Distribution of e-waste workers according to the activity categories.

Category	Benin (N = 159) n (%)	Côte d'Ivoire (N = 149) n (%)	All (N = 308) n (%)
Collectors	55 (34.6)	52 (34.9)	107 (34.7)
Recyclers	66 (41.5)	63 (42.3)	129 (41.9)
Repairers	38 (23.9)	34 (22.8)	72 (23.4)

were recyclers and 23% were repairers.

3.2. Socio-Demographic Characteristics of Study Participants

Some sociodemographic characteristics of e-waste workers are shown in the Table 2. We can see that the e-waste work was mainly carried out by men. In all the population of e-waste workers, the mean age was 33.71 ± 10.96. Participants of this study ranged in age from 14 years to 69 years. In Benin more than half (55.3%) of study participants were under 30 years old while in Côte d'Ivoire only a quarter of participants (24.8%) were in the same category. 58.1% of participants had no formal or primary education. In Côte d'Ivoire 66.5% of e-waste workers had no formal or primary education while in Benin, a half of respondents having attained a secondary school education or university.

3.3. Seniority in the e-Waste Activity

According to Figure 2, more than 40% of e-waste workers had spent more than ten years in this activity. About 30% of them had spent less than five years. These proportions were very different in Côte d'Ivoire compared to Benin. In Côte d'Ivoire, 62.4% and 12.8% had spent respectively more than ten years and less than five years in the e-waste activity. In contrast in Benin, 25.2% and 42.1%

Table 2. Sociodemographic characteristics of e-waste workers.

Variables	Benin (N = 159) n (%)	Côte d'Ivoire (N = 149) n (%)	All (N = 308) n (%)
Sex			
Female	1 (0.6)	1 (0.7)	2 (0.6)
Male	158 (99.4)	148 (99.3)	306 (99.4)
Age in years: mean ± SD	30.52 ± 10.35	37.16 ± 10.58	33.71 ± 10.96
Age category			
14 - 19 years	19 (11.9)	6 (4.0)	25 (8.1)
20 - 29 years	69 (43.4)	31 (20.8)	100 (32.5)
30 - 39 years	40 (25.2)	58 (38.9)	98 (31.8)
40 - 49 years	20 (12.6)	37 (24.8)	57 (18.5)
50 - 69 years	11 (6.9)	17 (11.4)	28 (9.1)
Education			
None	25 (15.7)	46 (30.9)	71 (23.1)
Primary	55 (34.6)	53 (35.6)	108 (35.1)
Secondary 1	60 (37.7)	32 (21.5)	92 (29.9)
Secondary 2	14 (8.8)	11 (7.4)	25 (8.1)
University	5 (3.1)	7 (4.7)	12 (3.9)

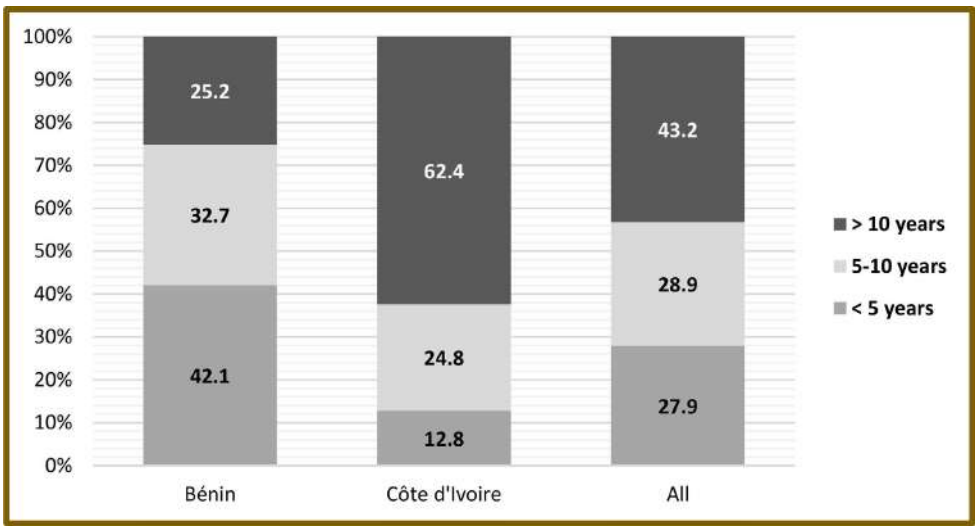

Figure 2. Number of years in the e-waste work reported by the study participants.

had spent respectively more than ten years and less than five years.

3.4. Activities, Protection, Living Place and Antecedents of Study Participants

Type of activities, wearing protective equipment, place of living, asthma history and cigarette smoking are summarized in the Table 3.

The main activities carried out by the study participants were respectively repairing (44.8%), buying or selling (40.3%), dismantling (31.8%) and collection or discharge (26.6%). A little more than a quarter (26.6%) declared wearing protective equipment but in Côte d'Ivoire only 14.8% of study participants declared wearing protective equipment. Generally, e-waste workers lived more than a kilometer from the work site (75.6%). They had no personal asthma history but 11.4% of them had a family asthma history. More than 20% of e-waste workers were smoking cigarettes.

3.5. Respiratory Disorders

Of all the e-waste workers, 20.1% presented respiratory disorders. In Benin they were 26.4% and 13.4% in Côte d'Ivoire (Table 4).

3.6. Factors Associated to Respiratory Disorders among e-Waste Workers

The bivariate analysis did not show a statistically significant association between the different variables and respiratory disorders (Table 5).

3.7. Association between E-Waste Activities and Respiratory Disorders

The results of the multivariate analysis are summarized in Table 6. The result of logistic regression showed that the respiratory disorders among e-waste workers was not significantly associated to the type of activities.

Table 3. Distribution of respondents based on the type of activities and some practices.

Characteristics	Benin (N = 159) n (%)	Côte d'Ivoire (N = 149) n (%)	All (N = 308) n (%)
Type of activities			
Repairing	69 (43.4)	69 (46.3)	138 (44.8)
Buying or selling	48 (30.2)	76 (51.0)	124 (40.3)
Dismantling	48 (30.2)	50 (33.6)	98 (31.8)
Collection or discharge	42 (26.4)	40 (26.8)	82 (26.6)
Sorting	24 (15.1)	31 (20.8)	55 (17.9)
Burning	12 (7.5)	26 (17.4)	38 (12.3)
Removal of coating from electronic wires	9 (5.7)	24 (16.1)	33 (10.7)
Burning of wires only	13 (8.2)	19 (12.8)	32 (10.4)
Collection of ashes or wires after burning	0 (0.0)	9 (6.0)	9 (2.9)
Melting lead-acid batteries	0 (0.0)	6 (4.0)	6 (1.9)
Wearing protective equipment	60 (37.7)	22 (14.8)	82 (26.6)
Place of living			
On the work site	20 (12.6)	1 (0.7)	21 (6.8)
Off the work site, <1 km	30 (18.9)	24 (16.1)	54 (17.5)
Off the work site, >1 km	109 (68.6)	124 (83.2)	233 (75.6)
Personal asthma history	3 (1.9)	0 (0.0)	3 (1.0)
Family asthma history	26 (16.4)	9 (6.0)	35 (11.4)
Cigarette smoking	22 (16.4)	39 (26.2)	65 (21.1)

Table 4. Prevalence of respiratory disorders among e-waste workers.

Respiratory disorders	Benin (N = 159) n (%)	Côte d'Ivoire (N = 149) n (%)	All (N = 308) n (%)
Yes	42 (26.4)	20 (13.4)	62 (20.1)
No	117 (73.6)	129 (86.6)	246 (79.9)

Table 5. Bivariate analyses.

Characteristics	Respiratory disorders		p-value
	Yes (N = 62) n (%)	No (N = 246) n (%)	
Age category in years			
14 - 19	4 (16.00%)	21 (84.00%)	
20 - 29	29 (29.00%)	71 (71.00%)	0.07
30 - 39	13 (13.27%)	85 (86.73%)	

Continued

40 - 49	12 (21.05%)	45 (78.95%)	
50 - 69	4 (14.29%)	24 (85.71%)	
Education			
None	14 (19.72%)	57 (80.28%)	
Primary	29 (26.85%)	79 (73.15%)	
Secondary 1	10 (10.87%)	82 (89.13%)	0.05
Secondary 2	7 (28.00%)	18 (72.00%)	
University	2 (16.67%)	10 (83.33%)	
Number of years in the activity			
<5	21 (24.42%)	65 (75.58%)	
5 - 10	21 (23.60%)	68 (76.40%)	0.15
>10	20 (15.04%)	113 (84.96%)	
Wearing protective equipment			
Yes	16 (19.51%)	66(80.49%)	0.87
No	46 (20.35%)	180 (79.65%)	
Place of living			
On the work site	5 (23.81%)	16 (76.19%)	
Off the work site, <1 km	13 (24.07%)	41 (75.93%)	0.61
Off the work site, >1 km	44 (18.88%)	189 (81.12%)	
Family asthma history			
Yes	8 (22.86%)	27 (77.14%)	0.67
No	54 (19.78%)	219 (80.22%)	
Cigarette smoking			
Yes	16 (28.57)	40 (71.43%)	0.10
No	0 (0%)	9 (100%)	
Repairing			
Yes	35 (20.59%)	135 (79.41%)	0.82
No	27 (19.57%)	111 (80.43%)	
Buying or selling			
Yes	34 (18.48%)	150(81.52%)	0.38
No	28 (22.58%)	96 (77.42%)	
Dismantling			
Yes	41(19.52%)	169 (80.48%)	0.7
No	21 (21.43%)	77 (78.57%)	
Collection or discharge			
Yes	43 (19.03%)	183 (80.97%)	0.42
No	19 (23.17%)	63 (76.83%)	

Table 6. Multivariate analysis.

		OR*	95% Confidence Interval	p-value
Model 1				
Repairing				
	No			
	Yes	1.13	[0.61; 2.09]	0.71
Model 2				
Buying or selling				
	No			
	Yes	1.51	[0.83; 2.74]	0.18
Model 3				
Dismantling				
	No			
	Yes	1.14	[0.60; 2.14]	0.69
Model 4				
Collection or discharge				
	No			
	Yes	1.11	[0.56; 2.17]	0.77
Model 5				
Repairing				
	No			
	Yes	1.48	[0.71; 3.06]	0.29
Buying or selling				
	No			
	Yes	1.65	[0.87; 3.14]	0.13
Dismantling				
	No			
	Yes	1.20	[0.62; 2.31]	0.58
Collection or discharge				
	No			
	Yes	1.16	[0.55; 2.44]	0.69

*OR adjusted with age, education, seniority in the e-waste activity, wearing protective equipment, place of living, family asthma history and cigarette smoking.

4. Discussions

Most of the e-waste workers (72.1%) had more than 5 years in the activity and

the majority of them had more than 10 years of seniority. The similar results were observed in e-waste workers at Nigeria [19] [20] and Ghana [20] [21]. These results show that the activities related to e-waste sector in West Africa is not recent. About the wearing of protective equipment. We found that very few workers (26.6%) were wearing protective equipment. Previous studies reported that e-waste workers carried out their activities without protective equipment. [22] [23].

Not wearing protective equipment is an aggravating factor in workers exposure. However, for those who wear the protective equipment, it could be interesting to investigate if they have the appropriate equipment.

The first objective of our study was to determine the main activities in the e-waste sector in Abidjan and Cotonou. Our findings showed that repairing (44.8%), buying or selling (40.3%), dismantling (31.8%) and collection or discharge (26.6%) are the main activities carried out by the study participants. Srigboh *et al.*, (2016) found that the main activities performed by the e-waste workers in Ghana were respectively dismantling, sorting and selling [15].

The e-waste workers who have been working for many years and without protective equipment in these main activities identified especially in repairing, dismantling and collection or discharge are likely to be the most exposed.

In the further analysis, we focused on the prevalence of respiratory disorders detected by spirometry in the study population. 20.1% of e-waste workers presented respiratory disorders. Yohannessen *et al.*, (2019) had found that 25% of e-waste workers reported breathing problems [18]. In another study, it was also found that the prevalence of coughing symptoms among workers who recycle electronic waste was 22.5% [24].

In the multivariate analysis, we found that, for each activity the risk of having respiratory symptoms was not significantly different among those who reported engaging in this type of activity primarily compared to those who reported not engaging in this activity primarily. In addition, we found that the type of e-waste activities did not affect differently the presence of respiratory disorders among e-waste workers.

This can be explained by the fact that those who are not engaged in a given activity are engaged in another activity that exposes them just as much. We could more appreciate the presence of respiratory disorders among e-waste workers if they were compared with white collar workers.

5. Conclusion

The effect of exposure to e-waste on respiratory health of workers is not different according to the type of activities. At this stage, we can conclude that all the activities in e-waste sector are dangerous for human health. So, any policy that aims to reduce the risk of exposure on respiratory health must take into account all the e-waste workers regardless of the type of activities they perform in this sector.

6. Limitations

In this study, the main independent variables were focused on the different activities carried out by the e-waste workers. We think that the most limitation of our study could be a bias of classification. It was difficult to determine the main activity of each e-waste worker. However, the results of this study could be the baseline for this problem.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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