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Prevalence and Tasks Associated with Respiratory Symptoms among Waste Electrical and Electronic Equipment Handlers in Ouagadougou, Burkina Faso in 2019

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Abstract

Introduction: The uncontrolled management of waste electrical and electronic equipment (W3E) causes respiratory problems in the handlers of this waste. The objective was to study the stains associated with respiratory symptoms in W3E handlers. **Methods**: The study was cross-sectional with an analytical focus on W3E handlers in the informal sector in Ouagadougou. A peer-validated questionnaire collected data on a sample of 161 manipulators. **Results**: the most common W3E processing tasks were the purchase or sale of W3E (67.70%), its repair (39.75%) and its collection (31.06%). The prevalence of cough was 21.74%, that of wheezing 14.91%, phlegm 12.50% and dyspnea at rest 10.56%. In bivariate analysis, there were significant associations at the 5% level between W3E repair and phlegm (p-value = 0.044), between W3E burning and wheezing (p-value = 0.011) and between W3E and cough (p-value = 0.01). The final logistic regression models suggested that the burning of W3E and the melting of lead batteries represented risk factors for the occurrence of cough with respective prevalence ratios of 4.57 and 4.63. **Conclusion**: raising awareness on the wearing of personal protective equipment, in particular masks adapted by W3E handlers, favoring those who are dedicated to the burning of electronic waste and the melting of lead could make it possible to reduce the risk of occurrence of respiratory symptoms.

Keywords

Respiratory Symptoms, W3E, Associated Tasks, Ouagadougou

1. Introduction

The rapid growth of new technologies has led to an increase in the quantities of waste electrical and electronic equipment (W3E) [1]. Indeed, in 2019, 53.6 million tons of W3E were generated worldwide, of which 2.9 million tons were in Africa, and this amount of W3E generated could reach 74.7 million tons by 2030. In West Africa, 600,000 tons of W3E will be produced in 2019. Due to the composition of these wastes in valuable materials, their recovery and valorization is an increasingly widespread commercial activity throughout the world [2] [3]. Thus, their consumption increases each year by 2.5 million tons [2]. However, the handling of these wastes, in particular by recovery and treatment activities, represents a public health problem in some countries, especially developing ones, as in these countries the handling of W3E is done in the informal sector using uncontrolled methods, representing a risk to human health and the environment [3].

In developing countries, formal and efficient recycling facilities are rarely found [4]. For example, in West Africa in 2019, only 0.4% of listed W3E was properly collected and recycled [2]. These informal practices generally refer to manual dismantling, open burning and acid leaching [5].

Studies have also shown the link between the unregulated recycling of electronic waste and health problems. These include birth defects, reduced olfactory memory and cognitive capacity, cancer and respiratory disorders [6]-[10]. Toxic substances such as mercury, cadmium, lead and flame retardants are generally released during this uncontrolled management of W3E, representing a serious health risk not only for workers on recycling sites, but also for people living in the vicinity [11] [12]. Studies show high levels of lead in the air, dust, water and soil in uncontrolled recycling areas, suggesting a serious threat to the environment and human health [5]. Other studies show that workers at informal recycling sites have blood lead and cadmium levels above reference values, and high levels of arsenic in their urine [13]. In 2013, the Blacksmith Institute and Green Cross Switzerland ranked the Agbogbloshie e-waste processing site in Ghana as one of the world's top ten toxic threats.

This situation of uncontrolled management of electronic waste is justified by the ignorance of handlers about the health risks involved, and by the absence of legislation governing the treatment of electronic waste [2] [14] [15]. In fact, very few W3E handlers in Africa are aware of the health risks involved in handling this waste, despite the fact that there is a positive correlation between workers' knowledge of the risk and proper waste management [14]-[16]. And in West Africa in 2019, only 3 countries—Ghana, Nigeria and Ivory Coast—had W3E legislation in force [2].

To avoid this uncontrolled management of W3E and the resulting health consequences, some countries are adopting legislation to improve the management of this waste [16]. The reuse of electronic plastics in the construction sector is also being considered as an alternative to recycling this hazardous waste [12]. Emerging recycling operations are also beginning to emerge [17].

In short, this uncontrolled management of e-waste leads to health problems, particularly respiratory, for handlers, but the evidence base is relatively weak [13].

2. Materials and Methods

2.1. Study Framework

The city of Ouagadougou served as the setting for the study. It has a tropical savannah climate and two seasons, a dry season and a rainy season. An exploratory survey to assess the risks associated with handling W3E in West Africa identified 70 W3E processing sites, with 381 W3E handlers.

2.2. Type, Period and Study Population

This is a cross-sectional study with analytical aims, which took place from June to December 2019.

The study population was made up of W3E handlers in the informal sector, *i.e.* W3E repairers, reclaimers and recyclers.

2.3. Sampling

The sample size was 161 handlers, including 56 reclaimers, 65 repairers and 40 recyclers. A stratified sampling design with random selection within each stratum (reclaimers, repairers, recyclers) was applied.

The sample size was determined by the Schwartz formula with $n = Z\alpha^2 pq/i^2$ with:

n sample size

p = 24.7% is the prevalence of respiratory problems occurring among D3E handlers in Chile (Yohannessen *et al.*, 2019).

$$q = 1 - p = 75.3\%$$

$$\alpha = 5\% \text{ hence } Z\alpha = 1.96$$

$$i = 0.07 \text{ (desired precision)}$$

$$n = [(1.96)2 \times 0.247 \times 0.753/(0.07)^2] = 145.82.$$

We added 10% to cover cases of non-response, which brings the final size to 161 handlers.

The calculation of the size of each stratum in the sample was carried out by multiplying the weight of each stratum in the sampling frame by the calculated sample size. The following table presents the weight of each stratum in the sampling frame and the size of each stratum in the sample.

Strata Weight of strata (%) Size of strata

Collectors	35	56
Repairers	40	65
Recyclers	25	40
Total	100	161

Within each stratum, a list of manipulators to be investigated was created by the research teams by simple random sampling.

If the consent of some was not obtained, a new simple random draw was carried out to replace them with others present in the sampling frame.

2.4. Data Collection

Data were collected using a validated questionnaire.

2.5. Variables

Several dependent variables were considered in this study. Each dependent variable corresponded to the presence of a respiratory symptom (cough, phlegm, dyspnoea and wheeze). The different treatment tasks represented the independent variables. Also potential confounding variables such as age, gender, education level, daily income, tobacco and alcohol consumption, dwelling location, cooking inside the bedroom, biomass fuel use and history of pulmonary tuberculosis were considered.

2.6. Data Processing and Analysis

Descriptive analyses for categorical variables were presented as headcounts and percentages. To verify the normality of the distribution of each continuous variable, the Shapiro-Wilk test was used. And for those continuous variables for which we were unable to reject the hypothesis of normality of distribution, they were presented for descriptive analysis, in the form of mean and standard deviation. Continuous variables with an asymmetric distribution were presented as median. In bivariate analysis, to study the association between different respiratory symptoms and different W3E processing tasks, the Chi-square or Fisher exact test was used. The Chi-square test was used when all the theoretical numbers in the contingency table were greater than five. In cases where at least one theoretical number was less than five, the Fisher exact test was used.

Logistic regression models were used to study the effect of different W3E processing tasks on the presence of respiratory symptoms. For the variable selection strategy, in order to take into account the epidemiological context and the objective of our study, we did not carry out an automatic variable selection. As a first step, we used a simple logistic regression model to perform a univariate analysis of the association between each treatment task and each respiratory symptom. The treatment task at the end of the univariate analysis with a given respiratory symptom that had a p-value<0.20 was entered into a logistic regression model adjusted for the various confounding factors. Tests were performed at a significance level of 5%, and confidence intervals for the regression models were calculated at a 95% confidence level. Statistical analyses were performed using

STATA version 14 software.

2.7. Ethical Aspects

The following ethical considerations were respected:

- The favorable opinion of the institutional ethics committee for health research.
- Non-disclosure of data and documents to unauthorized persons.
- Appropriate use of statistical procedures.

3. Results

3.1. Socio-Demographic Characteristics

Table 1 shows the socio-demographic characteristics of W3E handlers. The majority of handlers were men (98.94%). The median age was 33. Over 95% had a daily income of over 1000 FCFA. More than two-thirds of the handlers had attended school, *i.e.* 75.78%. The majority had completed primary and lower secondary school, with proportions of 36.02% and 24.84 respectively.

Table 1. Socio-demographic characteristics of respondents.

Variables	Number (%)	Median
Gender		
Female	3 (1.86)	
Male	158 (98.14)	
Age (in years)		33
Daily income		
Maximum 600 FCFA	1 (0.62)	
Between 601 and 1000 FCFA	5 (3.11)	
Between 1001 and 1500 FCFA	22 (13.66)	
Between 1501 and 2000 FCFA	36 (22.36)	
Between 2001 and 2500 FCFA	20 (12.42)	
Between 2501 and 3000 FCFA	22 (13.66)	
Between 3001 and 3500 FCFA	31 (19.25)	
More 3500 FCFA	17 (10.56)	
Do not know	7 (4.35)	
Education level		
None	39 (24.22)	
Primary	58 (36.02)	
Secondary 1st level	40 (24.84)	
Secondary 2nd cycle	12 (7.45)	
University	12 (7.45)	

3.2. Waste Electrical and Electronic Equipment Processing Tasks

Figure 1 shows the main tasks carried out by handlers over the last three months in handling W3E. The most common task performed by W3E handlers was purchasing or marketing W3E (67.70%), followed by repairing W3E (39.75%) and collecting W3E (31.06%).

3.3. Wearing Protective Equipment

Over half (63.5%) of all respondents do not wear or regularly use protective clothing and/or equipment at work. The safety equipment most commonly used by respondents are gloves (76.5%), long pants (68.2%), rubber-soled boots or shoes (68.3%), and dust masks or respirators (45.2%), as shown in Figure 2.

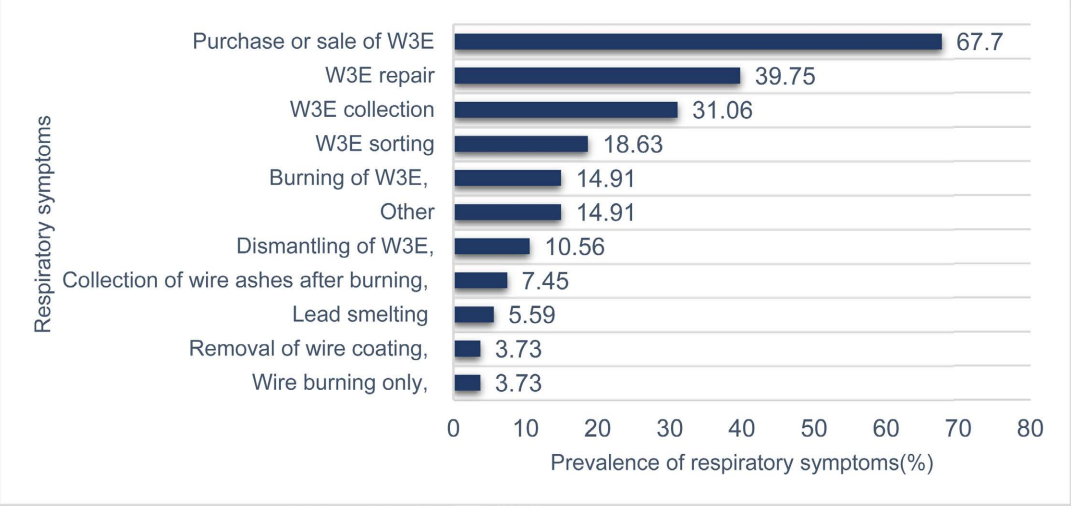

Figure 1. W3E processing tasks.

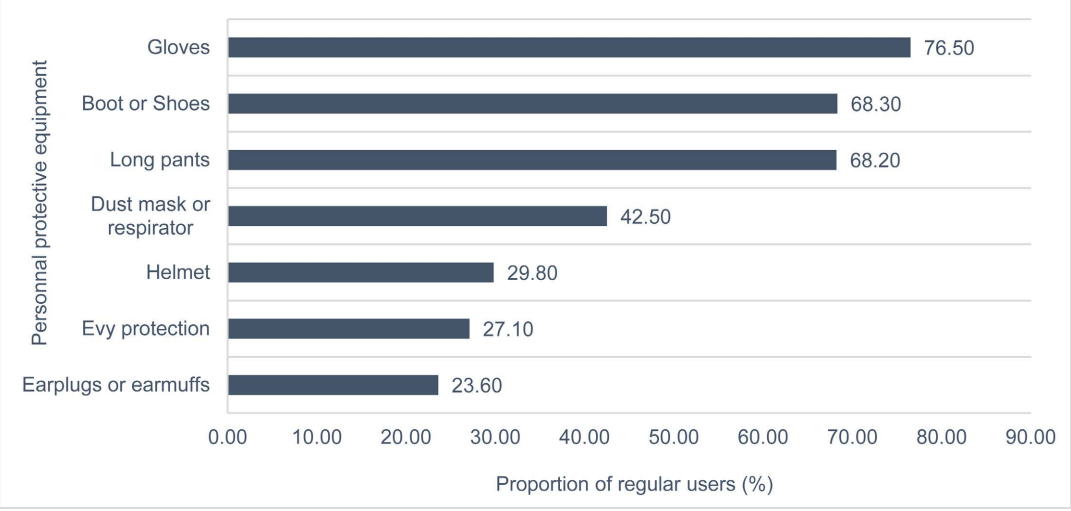

Figure 2. Proportion of regular users of personal protective equipment.

3.4. Prevalence of Different Respiratory Symptoms

The prevalences of the various respiratory symptoms are shown in Figure 3.

Coughing was the most common respiratory symptom in the W3E handler population, with a prevalence of 21.74%. The prevalence of wheezing was 14.91%, that of phlegm (discharge of mucus from the chest) 12.50%.

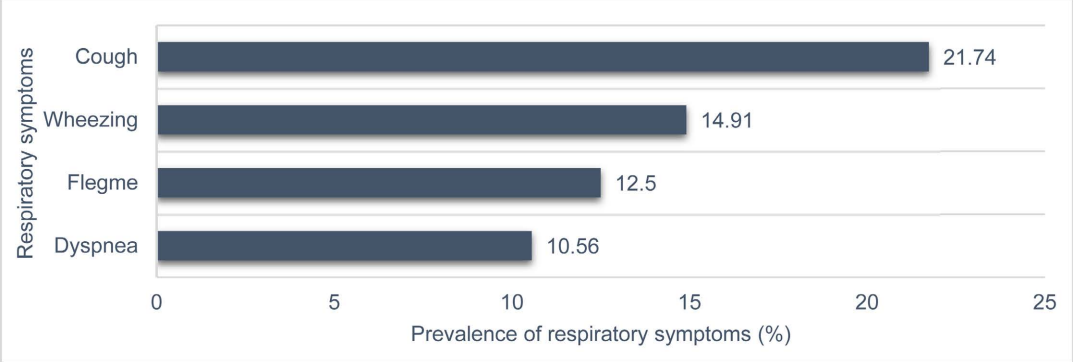

Figure 3. Prevalence of respiratory symptoms (%).

3.5. Spirometry Results

Spirometry was performed on 161 D3E handlers, and the results are presented in Table 2.

Table 2. Distribution of handlers according to spirometry results.

Variables	Weighted number	Weighted percentage (%)
Spirometry result		
Normal	158	97,9
TVO	3	2,1
TVR	0	0,0
TVM	0	0,0
TVO Distal	0	0,0
Unknown	0	0,0
Presence of obstruction according to GOLD criteria		
Yes	3	2,1
No	158	97,9
Severity of functional disorder*		
Mild	1	
Moderate	2	
Severe	0	
Very severe	0	

3.6. Bivariate Analysis

Table 3 presenting the results of association tests in bivariate analysis between

the various respiratory symptoms and the different W3E processing tasks, shows that there were significant associations at the 5% threshold between W3E repair and phlegm (p-value = 0.044), between W3E burning and wheezing (p-value = 0.011) and between W3E burning and coughing (p-value = 0.0).

3.7. Multivariate Analysis

In multivariate analysis, a logistic regression model adjusted on the different confounding variables was used only to search for relationships between treatment tasks and respiratory symptoms that had a significant association at the 20% threshold in univariate logistic regression. Table 4 shows that, adjusted for the various confounding variables, W3E burning and lead battery melting are the tasks associated with the onset of cough, with p-values of 0.008 and 0.047 respectively.

Table 3. Results of association tests in bivariate analysis between respiratory symptoms and different W3E processing tasks.

Respiratory symptoms	Purchase or marketing of W3E	Repair of W3E	Collection of W3E	Sorting of W3E	Removing wire coatings	Dismantling W3E	Burning W3E	Burning wire only	Collecting wire ash after combustion Lead	Lead smelting
Wheezing	0.722[a]	0.835[a]	0.828[a]	0.161[b]	1.00[b]	0.721[b]	0.011[b]	0.219[b]	0.390[b]	0.133[b]
Cough	0.901[a]	0.228[a]	0.236[a]	0.814[a]	0.612[b]	0.533[b]	0.010[b]	0.117[b]	1.000[b]	0.104[b]
Phlegm	0.799[a]	0.044[a]	0.270[a]	0.769[b]	1.00[b]	0.133[b]	1.00[b]	1.000[b]	1.000[b]	1.000[b]
Dyspnea	0.172[a]	0.899[a]	0.690[a]	0.319[b]	0.122[b]	0.696[b]	0.140[b]	0.494[b]	1.000[b]	0.055[b]
Asthma	-	-	-	-	-	-	-	-	-	-

[a]Chi-square test; [b]Fisher exact test.

Table 4. Results of logistic regression adjusted on confounding variables between W3E processing tasks and respiratory symptoms.

Results	Wheezing			Cough			Expectoration			Dyspnea		
	RP adjusted	P-value	IC 95%	RP adjusted	P-value	IC 95%	RP adjusted	P-value	IC 95%	RP adjusted	P-value	IC 95%
Repairing W3E												
No*	-			-			1.00			-		
Yes	-	-	-	-	-	-	2.73	0.088	[0.86; 8.68]	-	-	-
Sorting of W3E												
No*	1.00			-			-			-		
Yes	1.94	0.253	[0.62; 6.06]	-	-	-	-	-	-	-	-	-
Removing wire coating												
No*	-			-			-			1.00		
Yes	-	-	-	-	-	-	-	-	-	4.27	0.163	[0.56; 32.95]

*: reference modality; RP adjusted: Prevalence ratio adjusted for gender, age, daily income, education, smoking status, alcohol consumption, dwelling location, indoor cooking and biomass fuel use; CI 95%: 95% confidence interval.

4. Discussions

This study explored different respiratory symptoms and associated tasks among informal sector W3E handlers in Ouagadougou, Burkina Faso.

The results suggested that the most common tasks for handlers were purchasing or marketing W3E and repairing it. The prevalence of cough was 21.74%, wheeze 14.91%, phlegm 12.50% and dyspnea at rest 10.56%. Prevalence for coughing, wheezing and dyspnea was higher for recycling tasks than for collection and repair tasks. There were significant associations in bivariate analysis at the 5% threshold between W3E repair and phlegm, between W3E burning and wheezing, and between W3E burning and coughing. The proportion of coughing and wheezing was significantly higher among W3E burners than among handlers not engaged in this task. The proportion of phlegm was significantly higher among W3E repairers than among handlers who did not repair W3E. The results of the multivariate analysis showed that burning W3E and melting lead batteries were risk factors for coughing. From these results, we can generate a hypothesis according to which the burning of electronic waste and the smelting of lead batteries contribute to the occurrence of cough.

The predominance of W3E purchase and repair in the population of W3E handlers in Ouagadougou could be explained by the fact that there are more repairers and collectors compared to recyclers in this population. Ongondo *et al.* had also established in their study that the W3E sector in developing countries was characterized by high repair and reuse of W3E [1].

The prevalence of respiratory symptoms could be explained by the emission of toxic substances during the processing of electronic waste. Indeed, heavy metals such as mercury, cadmium and lead are generally released during the processing of electronic waste [12]. These W3E processing tasks then have negative consequences on the respiratory health of workers, due to the emission of heavy metals during processing [11] [18]. These transition metal particles are deposited in the respiratory tract, causing adverse effects on respiratory health [18] [19]. For example, Amoabeng *et al.* found average levels of exposure to fine particles to be significantly twice as high in workers at a W3E processing site, compared with those found in the population of a non-exposed area [10]. However, the prevalence of these respiratory symptoms in the population of W3E handlers in the informal sector of Ouagadougou was all lower than those observed in other informal sector professionals. This result could be explained by the fact that not all W3E handlers are exposed to heavy metal particles. Indeed, during certain tasks, such as the purchase or marketing of W3E and its repair, the emission of toxic substances seems unlikely.

The significant association in bivariate analysis between W3E burning and coughing and wheezing means that the differences in the prevalence of coughing and wheezing observed between W3E burners and non-burners are very unlikely to be due to chance. Multivariate analysis also established that W3E burning was a risk factor for coughing, with a prevalence ratio of 4.57. This means that e-waste

burners are 4.57 times more likely to have a cough than handlers who don't burn waste. These results could be explained by the increased emission of certain toxic substances harmful to respiratory health when burning W3E. Indeed, Soetrisno *et al.* found higher concentrations of lead, manganese and mercury at W3E burning sites [8]. And Amoabeng *et al.*, observed higher concentrations of suspended particulates in W3E burners over the seasons, establishing that waste burners were the category of workers most exposed to suspended particulates [10]. All these results explain the association between W3E burning and coughing and wheezing, and support our finding that W3E burning is a risk factor for coughing. Unlike the other respiratory symptoms, phlegm was associated with W3E repair at the 5% threshold in bivariate analysis. This can be explained by the fact that phlegm secretion is often preceded by other respiratory symptoms such as coughing. In the event of coughing, the perceived susceptibility of W3E handlers to certain recycling tasks as an aggravating factor would be high, which would logically lead them to steer clear of them and devote more time to other tasks such as repair.

These results have the advantage of having been obtained following a rigorous statistical approach. Indeed, the nature of the variable distribution and the preconditions for the various statistical tests were taken into account throughout the data analysis. We also opted for a non-automatic strategy of variable selection in our models, with a view to taking into account the epidemiological context and the objective of our study. In our approach, we also took into account the fact that handlers could perform several different tasks. However, there are a number of limitations. The first is inherent in the design of cross-sectional studies, which is not ideal for measuring associations. The second is the absence of certain potential confounding variables in our multivariate analysis, such as body mass index. Also, the absence of information on the level of heavy metal concentrations in the blood and air of the handlers can be highlighted as a limitation, insofar as this information could have better enabled us to generate a causal hypothesis between the different treatment tasks and respiratory symptoms.

Our work has provided more information on the W3E handling practices observed among handlers, as well as the prevalence of various respiratory symptoms and the tasks most at risk of causing respiratory symptoms in this population. This will enable us to prioritize public health interventions in the informal sector.

5. Conclusions

Numerous studies have suggested health and environmental risks associated with the mismanagement of W3E, however, the evidence base is insufficient, particularly in Burkina Faso.

The results suggested that the most common treatment tasks were the purchase or marketing of W3E and its repair. Cough was the most common respiratory symptom, with a prevalence of 21.74%. In bivariate analysis, there were sig-

nificant associations between the presence of phlegm and W3E repair (p-value = 0.044), wheezing and W3E burning (p-value = 0.006), and coughing and W3E burning (p-value = 0.01). And when adjusted for various confounding variables, e-waste burning and lead smelting were risk factors for coughing.

Ethics Committee Agreement

Favorable.

Authors' Contributions

All authors contributed to the study or writing of this article.

Conflicts of Interest

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

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