

Full Length Research Paper

Knowledge and management of WEEE by independent repairers in the city of Bouake in a context of health and environmental risk, 2022

S. I. Soumahoro^{1,2*}, D. P. Kouassi^{1,2}, A. M. Sokodogo¹, M. Coulibaly¹, A. D. Kouame^{1,2}, W. A. Tuo³, S. Yéo¹, A. Ouattara³, J. F. Konan Koffi³, N. J. Soumahoro³, A. Moumouni⁴, G. H. A. Yao^{1,2}, M-E. Ebouat^{2,3} and N. S. Dagnan⁵

¹Regional Office of the National Institute of Public Hygiene, Bouaké, Cote d'Ivoire.

²Department of Public Health, Alassane Ouattara University, Bouaké, Cote d'Ivoire.

³University Hospital of Bouaké, Cote d'Ivoire.

⁴Directorate of Immunizations Ministry of Public Health, Population and Social Affairs, Niger.

⁵Department of Public Health, Felix Houphouet Boigny University, Abidjan, Cote d'Ivoire.

Received 28 September, 2022; Accepted 21 November, 2022

Studies on waste management in Côte d'Ivoire are mostly focused on household and solid waste. It is appropriate to take a sustained look at the management of electrical and electronic equipment waste to better guide policies in this area. This work is a cross-sectional study covering the period from April 1, 2022 to June 30, 2022. The aim was to determine the knowledge and practices of the independent electrical and electronic repairers of the city of Bouaké in terms of electrical and electronic equipment waste (WEEE) management. A comprehensive sample of 307 people was interviewed by means of a questionnaire. The repairers interviewed had already heard of WEEE in 47.2% of cases. They had a good level of knowledge of WEEE in 85.5% of cases. In the final model in multivariate analysis, only the possession of a radio set at home had a significant influence on knowledge of WEEE. Repairers were unaware of the existence of D3E management legislation in 60.7% of cases; apart from humans (84.8%) who were most exposed to the dangers of inappropriate management of WEEE, other entities (air, soil, water, animals) would be polluted according to 36.6, 35.2, 4.1, and 3.4% of repairers, respectively. The most feared type of harm reported is injury (95.65%). Subjects dumped WEEE in a municipal landfill in 32.4% of cases. Sale, empowerment of pre-collection agents, and handing over to a recycling professional, cumulatively represent the most common practice (66.9%).

Key words: Electrical and electronic equipment waste (WEEE), repairers, knowledge, management, Côte d'Ivoire.

INTRODUCTION

The electrical and electronic waste (e-waste) are now one of the most difficult waste streams to manage (Anonyme,

2021). This flow presents major environmental challenges due to three main characteristics (Ducan, 2015), including

*Corresponding author. E-mail: ssoryibrahim@yahoo.fr. Tel: +2250140202418.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

the continued increase in volumes; the content of hazardous substances; and high processing costs. They impact human health by contaminating the food chain with toxic substances from rudimentary landfill and recycling processes or by directly impacting people who are exposed in a hazardous manner to toxic substances (Kiddee, 2013). The amount of electrical and electronic equipment waste (WEEE) generated globally has increased considerably over the last 10 years (Fischer et al., 2020; Frazzoli et al., 2010). In 2012, the generation of e-waste in industrialized countries was around 45.6 million tonnes (Mt) (Singhal, 2021).

Many countries, including China, Ghana, India, Nigeria, the Philippines, Thailand and Vietnam, have reported extensive informal recycling of electronic waste involving management problems. This management is one of the rapidly growing pollution problems around the world (Kiddee, 2013; Frazzoli et al., 2010; Orisakwe et al., 2019). The problem of WEEE management arises not only because of their increasing volume, but also because of the presence of hazardous substances that pose a risk to human health and the environment (Duncan, 2015; Kiddee, 2013). WEEE also contain substantial quantities of recoverable materials, such as metals (ferrous, non-ferrous, precious), plastics or glass, which are sometimes more valuable deposits than minerals (Ruediger, 2012). Globally, it is estimated that 2.3 million people die every year and suffer from WEEE work-related injuries and illnesses. The economic cost of these phenomena represents around 4% of global gross domestic product (Takala et al., 2014). WEEE, like other types of hazardous waste, are found either in public landfills of household waste, or in water bodies or in nature. These wastes are therefore a major problem and an appropriate response is needed (Gouvernement de Côte d'Ivoire, 2017a). In Cote d'Ivoire, there are practically no specialised structures for the management of WEEE (Effebi et al., 2020). Priority is given to the management of household waste, to which WEEE are mixed (Gouvernement de Côte d'Ivoire, 2017b). Studies on waste management in Côte d'Ivoire are mostly focused on household and solid waste. Studies on WEEE are particularly scarce. It is appropriate to take a sustained look at the management of WEEE to better guide policies on this issue. It is within this framework that this study is aimed at taking stock of the knowledge and practices in the management of WEEE by independent repairers of these equipment in the city of Bouaké. Bouaké is Côte d'Ivoire's second-largest economic and demographic city.

MATERIALS AND METHODS

A cross-sectional study was conducted from April 1, 2022 to June 30, 2022 in the geographical area of the commune of Bouaké. With a population of 832,371 according to the 2021 general population and housing census (GPHC), the commune of Bouaké is the second most populous in Côte d'Ivoire after Abidjan (Institut

National de la statistique de Côte d'Ivoire, 2021). The study population consisted of electrical and electronic equipment repairers in the city of Bouaké who carry out their activity in a strictly independent framework.

Any person aged at least 18 years, present at the time of visit to the workshop and working as a repairer, was included in the study.

The sampling techniques used were the purposive sampling and snowballing (Paul, 2015). A census was carried out which consisted from an identified repairer to find another person working in the same trade. The location of this person was provided by the first identified repairer. This was done until saturation levels were reached in the city of Bouaké. The saturation was attested by the meeting of those already interviewed (Paul, 2015). Thus, 307 people were met. The data collection method was the questionnaire method. This is a newly developed questionnaire in the absence of a pre-existing questionnaire on this topic. The data was collected using a questionnaire that included questions on: the socio-professional characteristics of the subject, knowledge about WEEE, and WEEE management practices. The pilot survey conducted over a period of one week allowed us to appreciate the rudimentary nature of the activity and to adapt the questions to it.

Measures of knowledge

Knowledge of WEEE comes first from knowledge about EEE

For knowledge of EEE, a subject who answered yes to at least two of the following four questions was considered to have good knowledge of EEE: equipment that runs on electricity, equipment that runs on a battery, equipment that runs on a battery, and equipment running over a power cable.

Then, for knowledge of WEEE, the following conditions had to be met to be considered as having a good level of knowledge of WEEE: have you ever heard of D3E; answer yes to at least three of the following five questions (Waste from EEE; Electrical and electronic equipment no longer in use; Electrical and electronic equipment that is discarded; Electrical and electronic equipment that can no longer be repaired; Electrical and electronic equipment no longer functioning); and answer in the affirmative to at least two of the following three questions (Is there a difference between rubber from household waste and D3E; Is there a difference between metal from household waste and that from D3E? Is there a difference between glass from household waste and glass from D3E).

The levels of knowledge were categorised based on our understanding of the subject and taking into account the rudimentary nature of the activity.

Measures of ecological management

The WEEE management process consists of three main steps: (1) collection, transport, storage; (2) pre-treatment/preparation (depollution, dismantling, sorting); (3) treatment and disposal (Anonyme, 2021). In the context of the rudimentary practice of the activity, we have limited the level of knowledge of ecological management to the issues of polluted entities and the most feared affection in the practice of the profession. This approach has been taken a step further by studying certain practices. Thus, according to the action taken in relation to WEEE, the practices have been classified into: acceptable location for anyone who claims to be dumping WEEE in a public dump; not an acceptable place for anyone who claims to have incinerated WEEE in the open air; difficult to locate for anyone who claims to have sold the WEEE and/or entrusted the WEEE to a pre-collection agent and/or recycling professional.

Independent variables

The independent variables are socio-professional characteristics.

Dependent variables

The variables to be explained are the level of knowledge about WEEE.

Crossing of variables

The data collected were analysed using Epi info.3.5.1 and SPSS 17.0. software. Univariate analysis of proportions was performed with Chi² calculation and a significance level set at 5%.

Ethical considerations

All research was conducted in accordance with the 2013 Helsinki Declaration. Verbal consent was sought and obtained from all repairers interviewed. The anonymity of the respondents was respected by assigning a unique code to each investigation record corresponding to an interviewed subject. The research was carried out after obtaining survey permission from the health authorities of the Gbêké region.

RESULTS**Socio-professional characteristics**

The subjects, all male, had a median age of 35.5 years with extremes of 20 and 72 years. They attended conventional school and were Muslim in 66.1 and 76.5% of cases, respectively. In 51.4 and 54.8% of cases, respectively, people lived in a couple and with at least one child. Televisions, fans, mobile phones and radios were the equipment most owned by households in 98, 94.8, 89.3 and 68.7% of cases, respectively. Televisions, fans, mobile phones and radios were the equipment most owned by households in 98, 94.8, 89.3, and 68.7% of cases, respectively. The median duration of exercise in activity is 10 years with extremes of 0 and 38 years. The respondents had received training from a relative before starting the activity in 44% of cases, were not organised in a repairers' association in 85.3% of cases and did not have any record of their professional activities in 93.8% of cases. The most repaired equipment are the television set (54.7%), the fan (49.8%), mobile phones (48.9%) and radio sets (44%) (Table 1).

Knowledge about WEEE

Electrical and electronic equipment is equipment that runs on electricity (96.4%), a battery (68.7%), a battery (74.6%) and a power cable (78.8%). According to the operationalisation plan, repairers had a good knowledge of the definition of electrical and electronic equipment in

87.3% of cases. Respondents had already heard of WEEE in 47.2% of cases. The following results concern the latter. Television (52.4%), training centres (36.6%) and social networks (35.9%) were the main channels of information about WEEE. WEEE is waste from EEE (89%); EEE that is no longer useful (87.6%), discarded (54.5%), cannot or no longer be repaired (91.7%), and no longer functions (73.8%). According to the operationalisation plan, the subjects had a good knowledge of the definition of these in 89.7% of the cases. Rubber from WEEE is different from that from household waste according to 91% of people. Metal from WEEE is different from that of household waste according to 93.8% of people. Glass from WEEE is different from that from household waste according to 70.3% of people. According to the study analysis plan, the repairers had a good level of knowledge about WEEE in 85.5% of the cases. In the study, univariate analysis found that the level of knowledge was influenced by three factors: the type of school attended, the possession of a radio at home, and the type of training received before starting the activity ($p < 0.05$). In the final model in multivariate analysis, only the possession of a radio at home significantly influenced knowledge of WEEE ($p < 0.05$) (Tables 2, 3 and 4).

Knowledge of WEEE management

The non-existence of a public municipal landfill for WEEE was reported by 78.6% of the repairers in the city of Bouaké. Repairers were unaware of the existence of WEEE management legislation in 60.7% of cases. Apart from humans (84.8%), who were the most exposed to the dangers of inappropriate WEEE management, the other entities (air, soil, water, animals) would be polluted according to 36.6, 35.2, 4.1 and 3.4% of the repairers, respectively. Subjects disposed of WEEE at a municipal landfill (acceptable location) in 32.4% of cases. Sale and empowerment of pre-collection agents and handing over to a recycling professional (location difficult to specify) accounted for a cumulative 66.9% of cases. Open-air incineration (unacceptable location) was carried out in 0.7% of cases (Table 5).

DISCUSSION

The results obtained during this study lead to make the following reflections.

Socio-professionnal characteristics

The male exclusivity of the 307 repairers of electrical and electronic equipment could be explained by the fact that traditionally, do-it-yourself and repair activities in households are the prerogative of men. It is therefore not

Table 1. Socio-professional characteristics.

Variable	Modalities	Numbers	Percentage
Age groups (year old)(n=306)	20-36	164	54
	37-72	142	46
Sex (n=307)	Male	307	100
Type of school attended (n=307)	Conventional	203	66.1
	Francoarab or koranic	51	16.6
	Not schooled	53	17.3
Religion (n=307)	Muslim	235	76.5
	Christian	70	22.8
Marital status (n=307)	As a couple	158	51.4
	Not as a couple	149	48.5
Number of children in the same household (n=307)	No	139	45.3
	At least one	168	54.7
Type of equipment owned (n=307)	Television	301	98
	Mobile phone	274	89.3
	Fan	291	94.8
	Radio set	211	68.7
	Refrigerator	105	34.2
	Air conditioner	12	3.9
	Computer	118	38.4
Duration in the activity (year) (n=307)	0 to 10	155	50.5
	11 to 38	141	46
Type of training received (n=307)	Training center	53	17.3
	Parent training	135	44
	Training by an acquaintance	119	38.8
Organisation in a repairers' association (n=307)	No	262	85.3
	Yes	45	14.7
Possession of a registration booklet (n=307)	No	288	93.8
	Yes	19	6.2
Type of equipment repaired (n=307)	Television	168	54.70
	Mobile phone	150	48.90
	Fan	153	49.80
	Radio set	135	44.00
	Refrigerator	62	20.20
	Air conditioner	20	6.50
	Computer	79	25.70

Source: Field Survey

surprising that the exercise of these activities for profit is mainly carried out by men. Management of WEEE in

Côte d'Ivoire remains a male-dominated informal sector (Effebi et al., 2020).

Table 2. Knowledge of electrical and electronic equipment (EEE).

Definition	Responses	Numbers	Percentage
Equipment that runs on electricity (n=307)	No	1	0.3
	Yes	296	96.4
	No answer	10	3.3
Equipment that runs on a battery (n=307)	No	47	15.3
	Yes	211	68.7
	No answer	49	16
Equipment that runs on a battery (n=307)	No	34	11.1
	Yes	229	74.6
	No answer	44	14.3
Equipment that runs on a power cable (n=307)	No	19	6.2
	Yes	242	78.8
	No answer	46	15

Source: Field Survey

Dieng et al. (2017) in Senegal found a male predominance of 97.7% in a population of EEE repairers. Repairers are young subjects. This young age is specific to the population in developing countries. According to the Ivorian National Health Development Plan 2016-2020 [Ministère de la santé de Côte d'Ivoire, 2020], approximately 66.67% of Ivorians are under the age of 25. Also, young age is the period par excellence when the individual is professionally active. Dieng et al. (2017) found that 65.9% of repairers were under 36 years old. The predominance of subjects who attended conventional schools can be explained by the urban character of the study area. The urban areas are mostly populated by people who have attended the conventional school, that is to say the school inherited from the colonial system. The city of Bouaké is a major trade hub. Many nationals of countries bordering Côte d'Ivoire have settled there with their families. These border countries are predominantly populated by people of Muslim faith. It is therefore not uncommon to find this religious predominance in many sectors of activity. The boom in household appliances and mobile phones has made many items of equipment accessible to lower-income households due to lower acquisition costs. Added to this are the many features (digital social networks, messaging and entertainment among others) available on equipment such as televisions and telephones. The relative length of time in the activity may be an asset in that the subjects may have notions about the risks involved in carrying out their activity in the absence of precautionary measures. On the other hand, this relative duration can cause a certain habituation in certain practices that will be very difficult to rectify. The lack of training makes it difficult to integrate into the professional fabric. In addition, it is

impossible for authorities in developing countries to include all those who have received training in the world of work. Self-employment is a lifeline for many people. It is therefore easier to learn a trade from a relative and/or acquaintance than from an unknown person. The respondents (repairers) are interested in WEEE management in order to reduce the unemployment rate, but without having a better qualification (Efebi et al., 2020). The near absence of organisation in association indicates the informal nature of the activity. One disadvantage is the difficulty of bringing them together in one place for a possible information and awareness-raising session on the protective measures to be taken in the course of their work. The absence of a registration book raises a problem of professionalisation of the activity and reinforces its informal character. A traceability of the repair activities carried out would represent a significant added value. In an increasingly competitive world, some differences, however small, can increase the customer base of some service providers. However, it must be recognised that the working environment is not always conducive to the development of certain ideas. Given that televisions, fans, mobile phones and radios are the equipment most owned by households, it is understandable that they are also the most prone to repair, probably due to their hyper-use.

Knowledge about WEEE

Respondents had already heard of WEEE in 47.2% of cases. The rest of the reflections therefore concern people who have already heard about WEEE, that is, 145 people. This proportion can be explained by the

Table 3. About waste of electrical and electronic equipment (WEEE).

Variable	Responses	Numbers	Percentage	
Have ever heard of WEEE	Yes	145	47.20	
	No	152	49.50	
Television (n=145)	Yes	76	52.4	
	No	28	19.3	
Radio set (n=145)	Yes	15	10.3	
	No	87	60	
Information channel	Written journals (n=145)	Yes	2	1.4
		No	99	68.3
Digital social networks (n=145)	Yes	52	35.9	
	No	57	39.3	
Training Centre (n=145)	Yes	53	36.6	
	No	78	53.8	
Waste from EEE (n=145)	Yes	129	89	
	No	5	3.4	
Electrical and electronic equipment no longer in use (n=145)	Yes	127	87.6	
	No	10	6.9	
Definition	Electrical and electronic equipment that is discarded (n=145)	Yes	79	54.5
		No	15	10.3
Electrical and electronic equipment that cannot or no longer be repaired (n=145)	Yes	133	91.7	
	No	11	7.6	
Electrical and electronic equipment that no longer works (n=145)	Yes	107	73.8	
	No	35	24.1	
Difference with household waste rubber	Yes	132	91	
	No	12	8.3	
Difference with household waste metal	Yes	136	93.8	
	No	9	6.2	
Difference with household waste glass	Yes	102	70.3	
	No	33	22.8	

Source: Field Survey

predominance of infectious diseases, generally evolving in an acute mode, in tropical zones compared to exposures with late manifestations. Indeed, in the tropics, the attention paid to infectious diseases means that information about these diseases and their risk factors is widely and regularly shared with the populations.

Television has always been the main information channel for people in urban areas. Anyone who has been through a training centre always has some bits of information about the positive and negative aspects of the activity they learned. Digital social networks are a formidable channel of information that must be taken into account.

Table 4. Factors associated with knowledge of WEEE.

Characteristics	Modalities	Knowledge of WEEE		Chi ²	P	ORbrut	CI
		Good	Insufficient				
		Number (%)	Number (%)				
Age groups (n=145)	20-36	63 (84)	12 (16)	0.289	0.591 ^{NS}	-	-
	37-72	61 (87.1)	9 (12.9)				
Type of school attended (n=134)	Conventional	103 (90.4)	11 (9.6)	10.51	0.001 ^S	1.51	1.05-2.16
	Francoarab or koranic	12 (60)	8 (40)				
Religion (n=144)	Christian	43 (91.5)	4 (8.5)	2.07	0.15 ^{NS}	-	-
	Muslim	80 (82.5)	17 (17.5)				
Marital status (145)	Not as a couple	55 (79.7)	14 (20.3)	3.58	0.06 ^{NS}	-	-
	As a couple	69 (90.8)	7 (9.2)				
Number of children in the same household (145)	No	54 (84.4)	10 (15.6)	0.121	0.728 ^{NS}	-	-
	At least one	70 (86.4)	11 (13.6)				
Ownership of television (n=145)	No	1 (50)	1 (50)	0.181	0.67 ^{NS}	-	-
	Yes	123 (86)	20 (14)				
Ownership of radio set (n=145)	Yes	99 (94.3)	6 (5.7)	23.63	0.0000 ^S	1.51	1.18-1.93
	No	25 (62.5)	15 (37.5)				
Ownership of mobile phone (n=145)	No	3 (60)	2 (40)	1.01	0.32 ^{NS}	-	-
	Yes	121 (86.4)	19 (13.6)				
Duration in the activity (n=137)	0 to 10 years	70 (84.3)	13 (15.7)	0.19	0.662 ^{NS}	-	-
	11 to 38 years	47 (87)	7 (13)				
Type of training received (n=145)	Training center	48 (100)	0 (0)	12.15	0.0000 ^S	1.27	1.15-1.41
	Acquaintance	76 (78.4)	21 (21.6)				
Organisation in a repairers' association (n=145)	No	103 (88.8)	13 (11.2)	3.79	0.052 ^{NS}	-	-
	Yes	21 (72.4)	8 (27.6)				
Possession of a registration booklet (n=145)	No	113 (86.3)	18 (13.7)	0.142	0.706 ^{NS}	-	-
	Yes	11 (78.6)	3 (21.4)				
Television repaired (n=145)	No	62 (81.6)	14 (18.4)	2.00	0.157 ^{NS}	-	-
	Yes	62 (89.9)	7 (10.1)				
Radio set repaired (n=145)	No	72 (82.8)	15 (17.2)	1.34	0.24 ^{NS}	-	-
	Yes	52 (89.7)	6 (10.3)				
Mobile phone repaired (n=145)	No	56 (84.8)	10 (15.2)	0.044	0.83 ^{NS}	-	-
	Yes	68 (86.1)	11 (13.9)				

Source : Field Survey

The big risk is the reliability of sources and the filtering of shared information. This challenge is difficult to overcome

due to the multiplicity of these networks, their ease of access and use.

Table 5. Knowledge of WEEE management by repairers.

Variable	Responses	Numbers	Percentage
Existence of a public municipal landfill for WEEE in the city of Bouake (N=145)	No	114	78.6
	Do not know	31	21.4
Existence of laws on WEEE management in Cote D'ivoire (N=145)	Do not know	88	60.7
	No	48	33.1
	Yes	9	6.2
Polluted entity (n=145)			
Air	Yes	53	36.6
	No	24	16.6
Ground	Yes	51	35.2
	No	39	26.9
Humans	Yes	123	84.8
	No	10	6.9
Animals	Yes	5	3.4
	No	80	55.2
Acceptability of the place according to the actions taken with the D3E (n=145)			
Difficult to locate		97	66.9
Acceptable location		47	32.4
Not an acceptable place		1	0.7
Most feared affection (N=92)			
Injury		88	0.9565
Respiratory problems		52	0.5652
Skin conditions		5	0.0543

Source : Field Survey

According to the operationalisation plan, the subjects had a good knowledge of the definition of these in 89.7% of the cases. People had a good knowledge of the difference between household waste and WEEE in 93.8% of cases. Since the elements (smell, colour, consistency) to which this difference relates involve the sense organs, it is important to point out their subjective nature. Repairers had a good level of knowledge of WEEE in 85.5% of cases. Singhal et al. (2021) carried out a study in India, 24% of the recyclers surveyed knew the meaning of D3E. In the present study, univariate analysis found that the level of knowledge was influenced by three factors: the type of school attended, the possession of a radio at home, and the type of training received before starting the activity. Those who attended the conventional school seemed to have a good level of knowledge compared to those in the Franco-Arabic and/or Koranic school. The conventional school undergoes regular programme changes in response to the

challenges of the times. These various changes have the advantage of widening the scope of knowledge of teachers of this system. Also, the different career profiles of this trade tend to sharpen their intellectual curiosity. These two elements can allow the teachers of this system to address various themes during the courses taught. People with a radio at home seemed to know more about WEEE than those without. It is not unusual to see radio sets on all day in some households. The profusion of channels in an increasingly competitive environment forces the media to deal with a number of no less important themes. These themes may include WEEE. Subjects who passed through a training centre would have a fairly good level of knowledge compared to those who would have been trained by a parent or acquaintance. This situation, which seems understandable, justifies the need for training in appropriate structures before starting any professional activity. In our final model in multivariate analysis, only the possession

of a radio at home significantly influenced knowledge of WEEE.

Knowledge of WEEE ecological management

Since 1996, Côte d'Ivoire has adopted an environmental code (law n° 96-766 of 3 October 1996) (Anonyme, 2021). This law, in the course of time and in the face of the challenges of the moment, has undergone numerous adjustments framed by various policies and strategies. These include the 1996 National Environmental Action Plan; the 2002 National Strategy for Sustainable Waste Management; the 2006 Strategic Plan for the Management of Hazardous Waste in the District of Abidjan; and the 2016-2020 National Waste Management Strategy (Anonyme, 2021). The political-military conflict of 2002-2011 may explain the failure to extend certain policies to the NOC zones of Côte d'Ivoire during this period. It must be acknowledged that it is only Decree 2017-217 of 5/4/2017 that explicitly and specifically mentions WEEE (Anonyme, 2021). The 2014 version of the Environmental Code, in Article 67, requires local authorities to have an environmental management plan (Ministère de l'environnement de Côte d'Ivoire, 2014). Ideally, the implementation of such a plan should cover persons or entities involved in any activity that generates waste, regardless of the nature of the waste and the setting in which the activity takes place. The fact that humans are particularly targeted is probably related to the idea that they are at the heart of the activity. This may justify them being the most exposed. However, the subjects would implicitly blame the physical nature of the activity.

The evidence is the most feared type of harm reported is injury (95.65%). Notwithstanding this, the low risk reported for other entities may be due to the lack of awareness among the general population, and repairers in particular, of the dangers of poor management of WEEE. As the manifestations of such pollution are mainly chronic, they do not receive sufficient attention from the competent authorities in the field, either in the scientific world or among decision-makers. Injuries were mentioned as a risk for recyclers (31%) in the study by Dieng et al. (2017). Fischer et al. (2020) in their study in Ghana reported a statistically significant high frequency of itchy red eyes, back pain and physical injuries among WEEE workers. The short- and long-term effects of exposure to hazardous substances in e-waste are not fully understood, but research has been conducted on the association between e-waste exposure and higher levels of chemicals and metals in human biological samples (Ruediger, 2012). In the study by Dieng (2017), even if the actors (recyclers) are unaware of the toxicity of the components of e-waste, due to their status as end-of-life products, they specify, among other things, the risks of illnesses (13%), environmental degradation (15%), and

nuisances and pollution (13%). The heterogeneous nature of hazardous exposures contributes to difficulties in studying the effects of electronic waste exposures. There are other aspects of e-waste exposure that can lead to adverse health effects. Although daily exposure is low, cumulative exposure is often high and extremely difficult to measure (Robinson, 2009; Tue et al., 2013). Even when the effects of a single chemical at certain levels are well studied, the effects of mixtures of hazardous e-waste substances are not well known. In a mixture of chemicals, some substances may have synergistic or modifying effects that could be extremely harmful (Robinson, 2009; Quinn et al., 2013). Much research is needed on exposure to e-waste and potential adverse health effects. There is no strong evidence linking occupational exposure to hazardous substances in e-waste to health effects. The potential causal relationship between exposure and the observed negative effects requires further and in-depth research. In addition, the combination of secondary chemicals from e-waste and biological agents is unknown (Orisakwe et al., 2019). First, dumping WEEE in a municipal landfill is a welcome practice. The difficulty lies in the fact that it would have been ideal to dump them in a landfill dedicated to WEEE. At present, the city of Bouaké has no such infrastructure, so repairers have no choice but to do with the only option at their disposal. A major concern is the sale and empowerment of pre-collection agents and handover to a recycling professional, which cumulatively represent the most adopted practice of repairers in relation to WEEE. Indeed, the informal nature of the activity makes the traceability of WEEE almost non-existent. This situation makes it impossible to trace the fate of this waste once it is no longer with the repairers. WEEE is seen as a source of wealth by household appliance repairers. Customers, in order to get rid of their so-called obsolete appliances, prefer not to collect them from the repairers. These equipments become a means of enrichment because they are used as spare parts to restore a second life (recycling) to other devices whose parts would be almost impossible to find on the market (Effebi et al., 2020).

Limitations

This study may have a number of weaknesses that are worth noting: permission was not obtained to take photographs from the interviewees; the study only concerned repairers who are not the only actors in the sector; no mention was made of the chemical constituents of the WEEE because it was physically impossible to take samples; and the rudimentary context in which the activity was carried out made it difficult to assess the level of management of WEEE. It was therefore almost impossible to provide a table analysing the relationship between socio-professional characteristics and WEE management.

The study design and sampling technique used may affect the study findings' generalizability. However, this work has the merit of having been carried out in view of the relatively late awakening on the subject at the African level.

Conclusion

This study revealed that a small proportion of EEE repairers had ever heard of WEEE. The level of knowledge on this subject was influenced by the possession of a radio at home. The repairers, who were mainly operating in an informal setting, were mainly selling WEEE, and had very little knowledge of the existence of WEEE legislation. They saw humans as the main victims of inappropriate management of WEEE. Studies with biological sampling of the actors would better inform the populations and the authorities on the need to better supervise the WEEE sector.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The authors thanks Prof. Oga Agbaya Serge, Prof. Manda Pierre, Mr. Romba Ousseni, Ms. Coulibaly Murielle, and Dr. Brou Senellart Jean Michel.

REFERENCES

- Anonyme (2021). Gestion Écologiquement Rationnelle des DEEE en Côte d'Ivoire. Directives Techniques 1 :141.
- Dieng D, Diop C, Sonko EhM, Gning JB, Djitte M, Gassama CID (2017). Gestion des déchets d'équipements électriques et électroniques (DEEE) au Sénégal: acteurs et stratégie d'organisation de la filière. *International Journal of Biological and Chemical Sciences* 11(5):2393-2407. DOI : <https://dx.doi.org/10.4314/ijbcs.v11i5.35>
- Duncan M (2015). « E-waste Prevention, Take-back System Design and Policy Approaches." Step Green Paper Series.92 p
- Efabi KR, Niamké KH, Bamba S (2020). Évaluation du mode de gestion des déchets électriques et électroniques dans le village d'Aboboté, district d'Abidjan, CÔTE D'IVOIRE. *Rev. Ivoir. Sci. Technol.* 35:121 – 137 ISSN 1813-3290, <http://www.revist.ci>
- Fischer D, Seidu F, Yang J, Felten MK, Garus C, Kraus T, Fobil JN, Kaifia A (2020). Health Consequences for E-Waste Workers and Bystanders—A Comparative Cross-Sectional Study. *International Journal of Environmental Research and Public Health* 17(5):1534. doi:10.3390/ijerph17051534
- Frazzoli C, Orisakwe OE, Dragone R, Mantovani A (2010). "Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios." *Environmental Impact Assessment Review* 30(6):388-399.
- Gouvernement de Côte d'Ivoire (2017a). Décret N°2017-217 du 5 avril 2017 portant gestion écologiquement rationnelle des Déchets d'Équipements Électriques et Électroniques, Ministère de l'Environnement et du Développement Durable, Journal Officiel de la République de Côte d'Ivoire.
- Gouvernement de Côte d'Ivoire (2017b). Décret n°2017-692 du 25 octobre 2017 portant création de l'Agence Nationale de Gestion des Déchets (ANAGED), Ministère de l'Environnement et du Développement Durable, Journal Officiel de la République de Côte d'Ivoire.
- Institut National de la statistique de Côte d'Ivoire (INS) (2021). Résultats globaux du recensement général de la population et de l'habitat 25 p.
- Kiddee P, Naidu R, Wong MH (2013). Electronic waste management approaches: an overview. *Waste management* 33(5) :1237-1250. doi: 10.1016/j.wasman.2013.01.006.
- Ministère de l'environnement et du développement durable de Côte d'Ivoire (2014). Nouveau code de l'environnement. 504 p.
- Ministère de la santé et de l'Hygiène Publique de Côte d'Ivoire (MSHP) (2016). Plan National de Développement Sanitaire (PNDS) 2016-2020; 1:88.
- Paul N'DA (2015). Recherche et méthodologie en sciences sociales et humaines: réussir sa thèse, son mémoire de master ou professionnel, et son article. Editions L'Harmattan.
- Orisakwe OE, Frazzoli C, Ilo CE, Oritsemuelebi B (2019). Public Health Burden of E-waste in Africa. *Journal of Health and Pollution* 9(22).
- Quinn LP, Roos C, Pieters R, Løken K, Polder A, Skaare JU, Bouwman H (2013). Levels of PCBs in wild bird eggs: considering toxicity through enzyme induction potential and molecular structure. *Chemosphere* 90(3):1109-1116. doi: 10.1016/j.chemosphere.2012.09.016.
- Robinson BH (2009). E-waste: an assessment of global production and environmental impacts. *Science of the total environment* 408(2) :183-191. doi: 10.1016/j.scitotenv.2009.09.044.
- Ruediger K (2012). Global e-waste initiatives, in: Stevels, A. (Eds.), *Waste Electrical and Electronic Equipment (WEEE) Handbook*, Woodhead Publishing Series in Electronic and Optical Materials. Woodhead Publishing pp. 3-16.
- Singhal D, Lyngdoh T, Prabhakaran P (2021). Knowledge, Attitude and Practice Study of Health Risks Among E-waste Recyclers in Delhi. *Journal of Health and Pollution* 11(29):210306. doi: 10.5696/2156-9614-11.29.210306.
- Takala J, Hämäläinen P, Saarela KL, Yun LY, Manickam K, Jin TW, Heng P, Tjong C, Kheng LG, Lim S, Lin GS (2014). Global estimates of the burden of injury and illness at work in 2012. *Journal of occupational and environmental hygiene* 11(5):326-337. doi: 10.1080/15459624.2013.863131.
- Tue NM, Takahashi S, Suzuki G, Isobe T, Viet PH, Kobara Y, Seike N, Zhang G, Sudaryanto A, Tanabe S (2013). Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non-dietary exposure in Vietnamese informal e-waste recycling sites. *Environment international* 51:160-167. doi: 10.1016/j.envint.2012.11.006.