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Occupational and Environmental Health Effects of Informal Electronic Waste Recycling - A Focus on Agbogbloshie, Ghana

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Abstract

The unregulated and unorganized structure of informal electronic waste recycling worksites exposes workers to numerous occupational hazards. This context also presents research challenges in collecting exposure data to establish linkages with adverse health effects and development of risk-mitigating strategies. This paper presents some findings from a 5-year multinational and multi-institutional collaboration of academic and government partners, which documented extensive occupational and environmental health conditions at the Agbogbloshie electronic waste site in central Accra, Ghana.

Keywords

Agbogbloshie; electronic waste; ergonomics; occupational health

1 Introduction

1.1 Background

Electronic waste (e-waste) is believed to be one of the most rapidly increasing components of the global waste stream [1]. The increase in e-waste has been fuelled by the increase in obsolescence and the desire to keep up with global advancement in technology. Large volumes of e-waste are legally and illegally dumped in developing countries such as Ghana where they are recycled as a form of livelihood [1–3]. Recycling of valuable metals including gold or copper contained in e-waste (e.g., discarded cell phones, computers, televisions, refrigerators, and automobiles) has become an important source of income, largely in the informal sector of emerging/developing or less-industrialized nations. These countries often lack the technical know-how and technological infrastructure to recycle e-

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waste in an ecologically safe and sustainable manner and this poses serious public health and environmental concerns. Informal e-waste recycling and scrap metal recovery consists primarily of scavenging and collecting e-waste items, sorting out items that can be reused or repaired and manual dismantling of items that are irreparable and/or non-functional [4,5]. The recycling process is carried out by low-wage, low skilled workers who are largely unaware about the associated exposure risks or about safe work practices to prevent or mitigate related adverse effects [1,2,6].

Agbogbloshie in Accra Ghana is one of the major e-waste recycling hubs in the world [7]. The recycling processes used at this site are predominantly manual and simple. Basic tools such as hammer and screw drivers are used for breaking apart (dismantling) electrical items to retrieve valuable metals such as copper, aluminium, silver and gold [2,3]. Open air burning, especially of insulated wires, is used to recover copper, iron and aluminium from items that cannot be dismantled [4]. Non-valuable fractions of e-waste are discarded at the dumpsite and subsequently burnt to reduce the volume of waste accumulated [8].

1.2 Problem Statement

The informal recycling process consists of the use of rudimentary methods which are hazardous and poses huge safety risks to workers and the environment [6,9–11]. A defining characteristic of workers in informal sectors is that they are not subject to national labor laws and standards. As a result, these workers are likely exposed to hazardous work conditions, including high levels of toxic chemicals with little or no social, economic or occupational protections. For the estimated two billion informal sector workers around the globe, there is a clear need for identifying and implementing the appropriate context-specific interventions in challenging work environments where unprotected workers face substantial risk from hazardous exposures and work conditions.

1.3 Objective

The objectives of this paper are to: (1) highlight some of the adverse health consequence of fast-growing e-waste in the global waste stream by showcasing such conditions at Agbogbloshie – the largest e-waste dumpsite in Africa, and (2) call attention to the need for continued research, including by the ergonomics community, to characterize and reduce work exposures and promote worker health and safety measures associated with informal e-waste recycling in emerging/developing economies.

2 Methodology

This study uses a hybrid design drawing up materials from both extant literature and new empirical studies conducted at the Agbogbloshie e-waste dumpsite in Accra, Ghana. These empirical studies include our own research and experiences during the 5-year collaborative research. The broad aim of this multinational collaboration was to increase multi-disciplinary understanding of the occupational and environmental risks associated with informal e-waste recycling, and to use the project's findings to inform evidence-based work interventions and policy.

In this collaboration various studies [3,9–14] used multidisciplinary combination of methods to investigate the environmental and health effects of e-waste recycling in Agbogbloshie. We collected and analyzed in the laboratory both biological and environmental samples in a longitudinal design at 4 time-points. Direct field observations were conducted to supplement quantitative data collected in the field. The areas of investigation included: evaluation of ergonomic risk factors and work-related musculoskeletal disorders among e-waste workers [3,14,15]; investigating the adverse cumulative exposures [11], including particulate matter discharge that determined air quality [9,13] and its effects on workers respiratory health. The results from these and other relevant studies on e-waste worker health are synthesized and summarized in this paper.

3 Results

Summary of findings of our research studies at Agbogbloshie speaks to significant health consequences of informal e-waste recycling activities on both environment and human health. Primitive recycling methods such as manual dismantling of electrical appliances and open air burning of predominantly copper wires at low temperatures are used in the recycling process. These rudimentary methods; including heavy and stressful lifting, are a source of high exposure to toxic chemicals and physical risk factors leading to undesirable health implications such as musculoskeletal pain and various adverse cardiovascular and respiratory health outcomes. The use of personal protective equipment by workers at Agbogbloshie is extremely rare despite all the health hazards associated with the manual recycling of e-waste.

3.1 Physical/ergonomic exposures and work-related musculoskeletal disorders

A preliminary investigation of the processes involved in manual e-waste recycling at Agbogbloshie and the associated ergonomic risk factors revealed that, self-reported sitting, standing, walking and manual material handling such as carrying, lifting and pushing/pulling of collecting carts were performed at varied frequency and intensity among e-waste workers [3,15]. Lifting and carrying activities were performed on five or more days in the workweek by dismantlers (60%) as well as collectors and burners (nearly 90%). Prolonged walking, sitting and standing was frequently reported by collectors (87%), dismantlers (82%) and burners (60%), respectively [15].

Dismantlers of e-waste assume non-neutral seated postures with excessive forward flexion and twisting of the trunk as well as high force exertion from manual use of hammers in the dismantling of non-functional electrical appliances. Collectors of e-waste were often exposed to high force exertion and contact stress as a result of pulling/pushing loaded collection carts over long distances [16].

An alarmingly high prevalence (90%) of work-related MSDs exists among e-waste workers [14] in Agbogbloshie, Ghana. Work-related musculoskeletal disorder symptoms were mostly reported in the lower back (65%), knee (39%), shoulder (37%), upper arm (30%), lower leg (27%) and neck (26%) (14). Prolonged work duration was significantly associated with MSDs, which were also significantly associated with the primary e-waste job category [14].

In addition, evidence of acute injuries such as cuts, lacerations, abrasions and scars were observed in 96.2% of e-waste workers [10]. Scars were prevalent on the skins of 93.6% of workers while 23.1% of workers had burns [10].

3.2 Environmental health effects

Manual dismantling of appliances and open air burning to isolate valuable metals create very harmful ambient conditions [11]. Styrofoam food containers and car tires are often added as fuel to sustain the burning process. These conditions expose child- and adult-workers as well as their family members and the general population to excessive doses of hazardous substances [17]. For example, burning of copper wires results in emission of dioxins and furans [18] while breaking (dismantling) of Cathode Ray Tubes (CRT) monitors with rudimentary tools to recover copper and steel, result in the release and inhalation of organic compounds such as flame retardants, formaldehyde and combustion products such as polychlorinated biphenyls (PCBs), polybromated diphenyl ethers (PBDE), furans and dioxins as well as hazardous cadmium dust and other pollutants [18]. Other harmful substances resulting from informal e-waste recycling include oxides of: a) Lead, b) Chromium and c) Mercury, often as toxic fumes, as well as other heavy metal accumulation in water, soil and food [19–22].

Besides the hazardous components being processed, e-waste also produces several toxic by-products likely to affect the health of the adjacent general population [17], particularly children who need more specific protection [5,23,24]. For instance, while still growing, children’s intake of water, air and food as a proportion of body weight is significantly larger compared with adults; thus, considerably increasing the risk of hazardous chemical absorption. Additionally, functional systems such as the: (i) immune system, (ii) digestive system, (iii) reproductive system and (iv) central nervous system are still developing and exposure to toxic substances, by hampering further development, might cause irreversible damage.

E-waste workers at Agbogbloshie are also exposed to high levels of particulate matter [9,11] which predisposes them to a decline in lung function and the risk of developing small airway diseases like asthma or chronic obstructive pulmonary disease [9].

4 Discussion

Agbogbloshie has been the dumping ground for discarded electronic products, mainly from Europe and North America. Besides harbouring one of Accra’s largest food markets, some 40,000 people are said to live and work in the wider area and all together, some 250,000 people including a floating day-time population are likely to be directly exposed to the fumes released during e-wastes recycling activities. Some 1.5 million people are believed to be indirectly exposed via the food chain. The unregulated and unorganized structure of informal e-waste recycling worksites leads to a hazardous work environments.

The high physical demands of manual recycling activities subject workers to high risk of acute injuries and work-related musculoskeletal disorders, predominantly low back pain. Our studies reported high prevalence of low back pain among the e-waste workers as a result

of frequent manual material handling tasks such as carrying, lifting, pushing and pulling of loaded collecting carts, which exposes workers to non-neutral work postures and high force exertion over prolonged work durations. The use of hammer and chisel to break apart electronic waste may have accounted for the prevalence of upper limb musculoskeletal pain. Prolonged walking over uneven ground in search of e-waste from neighboring communities could be contributing to the high prevalence of lower extremity disorders among e-waste collectors.

Informal e-waste recycling worksites present challenges to research, such as difficulties in collecting work-related, time-varying, job-specific exposure data that would establish linkages with adverse health effects and guide the design of locally-adapted risk-mitigating strategies. New ergonomics perspectives, exposure assessment tools and methods suited to informal work settings are needed to overcome some of these research challenges.

5 Conclusion

E-waste represents a major global health challenge in the 21st Century. Growing evidence of hazardous work conditions and diverse sources of environmental pollution driven by practices used to recover valuable metals and dispose waste in the informal e-waste recycling sector have raised considerable global concerns. Upstream and downstream solutions are therefore urgently needed to redesign the structures for handling fast growing global e-waste production. Confronting this challenge will require interdisciplinary cooperation of multiple international stakeholders.

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References

1. Lundgren K: The global impact of e-waste: Addressing the challenge (2012). https://ilo.org/sector/Resources/publications/WCMS_196105/lang--en/index.htm
2. Amankwaa EF: Livelihoods in risk: exploring health and environmental implications of ewaste recycling as a livelihood strategy in Ghana. J. Mod. Afr. Stud 51(4), 551–575 (2013). 10.1017/S0022278X1300058X
3. Acquah AA, D'Souza C, Martin B, Arko-Mensah J, Nti AA, Kwarteng L, Fobil JN: Processes and challenges associated with informal electronic waste recycling at Agbogbloshie, a suburb of Accra, Ghana. Proc. Hum. Factors Ergon. Soc. Annu. Meet 63(1), 938–942 (2019). 10.1177/1071181319631219 [PubMed: 33664560]
4. Akormedi M, Asampong E, Fobil JN:Working conditions and environmental exposures among electronic waste workers in Ghana. Int. J. Occup. Environ. Health 19(4), 278–286 (2013). 10.1179/2049396713Y.0000000034 [PubMed: 24588034]
5. Binion E, Gutberlet J: The effects of handling solid waste on the wellbeing of informal and organized recyclers: a review of the literature. Int. J. Occup. Environ. Health 18(1), 43–52 (2012). 10.1179/1077352512Z.0000000001 [PubMed: 22550696]

6. Yu EA, Akormedi M, Asampong E, Meyer CG, Fobil JN: Informal processing of electronic waste at Agbogbloshie, Ghana: workers' knowledge about associated health hazards and alternative livelihoods. Glob. Health Promot. 24(4), 90–98 (2017). 10.1177/1757975916631523
7. Davis JM, Akese G, Garb Y: Beyond the pollution haven hypothesis: where and why do e-waste hubs emerge and what does this mean for policies and interventions? Geoforum 98, 36–45 (2019). 10.1016/j.geoforum.2018.09.020
8. Amoyaw-Osei Y, Agyekum OO, Pwamang JA, Mueller E, Fasko R, Schluep M: SBC e-Waste Africa Project Ghana e-Waste Country Assessment Yaw Amoyaw-Osei-Green Advocacy Ghana Obed Opoku Agyekum-Green Advocacy Ghana (2011). https://www.basel.int/Portals/4/BaselConvention/docs/eWaste/E-wasteAssessmentGhana.pdf
9. Amoabeng Nti AA, Arko-Mensah J, Botwe PK, Dwomoh D, Kwarteng L, Takyi SA, Fobil JN: Effect of particulate matter exposure on respiratory health of e-waste workers at Agbogbloshie, Accra, Ghana. Int. J. Environ. Res. Pub. Health 17(9), 3042 (2020). 10.3390/ijerph17093042
10. Adusei A, Arko-Mensah J, Dzodzomenyo M, Stephens J, Amoabeng A,Waldschmidt S, Fobil J: Spatiality in health: the distribution of health conditions associated with electronic waste processing activities atAgbogbloshie Accra.Ann. Glob.Health 86(1), 31 (2020). 10.5334/aogh.2630
11. Kwarteng L, Baiden EA, Fobil J, Arko-Mensah J, Robins T, Batterman S: Air quality impacts at an e-waste site in Ghana using flexible, moderate-cost and quality-assured measurements. GeoHealth 4(8) (2020). 10.1029/2020GH000247
12. Laskaris Z, Milando C, Batterman S, Mukherjee B, Basu N, O'neill MS, Fobil JN: Derivation of time-activity data using wearable cameras and measures of personal inhalation exposure among workers at an informal electronic-waste recovery site in Ghana. Ann. Work Exposure. Health (2019). 10.1093/annweh/wxz056
13. Takyi SA, Basu N, Arko-Mensah J, Botwe P, Amoabeng Nti AA, Kwarteng L, Fobil JN: Micronutrient-rich dietary intake is associated with a reduction in the effects of particulate matter on blood pressure among electronic waste recyclers at Agbogbloshie, Ghana. BMC Pub. Health 20(1), 1067 (2020). 10.1186/s12889-020-09173-8 [PubMed: 32631289]
14. Acquah AA, Arko-Mensah J, D'Souza C, Martin B, Quakyi IA, Robins TG, Fobil JN: Prevalence ofwork-related musculoskeletal disorders among electronicwasteworkers at Agbogbloshie in Accra, Ghana. In: Proceedings of the Annual Conference of the International Society for Environmental Epidemiology, p. 92. Utrecht, Netherlands, August 2019, vol. 3, pp. 2–3 (2019). 10.1097/01.EE9.0000605616.87684.ec
15. Acquah AA, D'Souza C, Martin B, Arko-Mensah J, Botwe PK, Tettey P, Dwomoh D, Nti AA, Kwarteng L, Tyaki S, Quaki I, Robins T, Fobil JN: A preliminary assessment of physical work exposures among electronic waste workers at Agbogbloshie, Accra Ghana. International Journal of Industrial Ergonomics, in press (2021). 10.1016/j.ergon.2021.103096
16. Acquah AA,D'Souza C,Martin B, Arko-Mensah J,Nti AA,Kwarteng L, Fobil JN: Development of an observation-based tool for ergonomic exposure assessment in informal electronic waste recycling and other unregulated non-repetitive work. Proc. Hum. Factors Ergon. Soc. Annu. Meet 64(1), 905–909 (2020). 10.1177/1071181320641216 [PubMed: 33731982]
17. Fischer D, Seidu F, Yang J, Felten MK, Garus C, Kraus T, Kaifie A: Health consequences for e-waste workers and bystanders—a comparative cross-sectional study. Int. J. Environ. Res. Pub. Health 17(5), 1534 (2020). 10.3390/ijerph17051534
18. Prakash S, Manhart A, Amoyaw-Osei Y, Agyekum O: Socio-economic assessment and feasibility study on sustainable e-waste management in Ghana. Öko-Institut e.V. - Institute of Applied Ecology, vol. 49 (2010). https://ressourcenfieber.org/publications/reports/2010-105-en.pdf
19. Srigboh RK,Basu N, Stephens J, Asampong E, Perkins M, Neitzel RL, Fobil J: Multiple elemental exposures amongst workers at the Agbogbloshie electronic waste (e-waste) site in Ghana. Chemosphere 164, 68–74 (2016). 10.1016/j.chemosphere.2016.08.089 [PubMed: 27580259]
20. Caravanos J, Clark E, Fuller R, Lambertson C: Assessing worker and environmental chemical exposure risks at an e-waste recycling and disposal site in Accra, Ghana. J. Health Pollut 1(1), 16–25 (2011). 10.5696/jhp.v1i1.22
21. Asante KA, Agusa T, Biney CA, Agyekum WA, Bello M, Otsuka M, Tanabe S: Multi-trace element levels and arsenic speciation in urine of e-waste recycling workers from Agbogbloshie,

Accra in Ghana. Sci. Total Environ 424, 63–73 (2012). 10.1016/j.scitotenv.2012.02.072 [PubMed: 22446112]

22. Feldt T, Fobil JN, Wittsiepe J, Wilhelm M, Till H, Zoufaly A, Göen T: High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana. Sci. Total Environ 466–467, 369–376 (2014). 10.1016/j.scitotenv.2013.06.097 [PubMed: 25437764]
23. Robinson BH: E-waste: an assessment of global production and environmental impacts. Sci. Total Environ 408(2), 183–191 (2009). 10.1016/j.scitotenv.2009.09.044 [PubMed: 19846207]
24. Porta D, Milani S, Lazzarino AI, Perucci CA, Forastiere F: Systematic review of epidemiological studies on health effects associated with management of solidwaste. Environ. Health A Glob. Access Sci. Source. BioMed Central (2009). 10.1186/1476-069X-8-60