Orginal Article

Informal processing of electronic waste at Agbogbloshie, Ghana: workers' knowledge about associated health hazards and alternative livelihoods

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Abstract:
Aims: This study was conducted to investigate the electronic waste workers' knowledge about the potential health hazards associated with their work as well as the livelihood alternatives that they would prefer if they were given the opportunity.
Methods: A qualitative cross-sectional study was conducted to gather empirical information on e-waste workers' knowledge about the potential hazards associated with their work and the livelihood alternatives to e-waste recycling with a sample consisting of twenty all-male electronic waste workers at the Agbogbloshie scrap metal yard in Accra, Ghana.
Results: Electronic waste workers at Agbogbloshie were found to be exposed to a variety of injuries and illnesses. The workers' knowledge of the association between their health status and their work was generally poor. Apart from the physical injuries, they did not believe their work played any negative role in their health conditions. They preferred occupations such as farming or professional driving located in the northern region of Ghana to be closer to their families.
Conclusions: The study concludes that the low knowledge level of the workers on the hazards that are associated with their work has implications for them accepting technologies to protect them and the natural environment from contamination. It is therefore imperative for any intervention to consider the current low level of knowledge and actively educate the workers to raise their awareness level, taking into account the provision of opportunities for workers to acquire applicable skills for future employment in other fields. (Global Health Promotion, 2017; 24(4): 90–98)

Keywords: electronic waste, e-waste recycling, Agbogbloshie, Ghana, livelihood alternatives, health hazards, knowledge, awareness

Introduction

Technological advancement on a global scale has created a culture of 'newer, faster, better,' leading to the rapid consumption and replacement of equipment such as televisions, refrigerators, mobile phones, and computers, and decreasing the useful lifespan of electric and electronic equipment (EEE) (1–5). This global technological advancement has therefore meant an increase in the proportion of electronic and electrical materials in the global solid waste stream known as electronic waste (e-waste)

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(3,5,6). According to a report by the International Labour Organization (ILO), e-waste is currently the largest growing waste stream and it is hazardous, complex, and often expensive to treat in an environmentally sound manner with an added general lack of legislation or enforcement of its safe disposal (7). Globally, more than 50 million tons of e-waste were discarded in 2009 (8) and more than 72 million tons are expected to be generated by the end of 2015 (5–7, 9,10). Of the e-waste produced in high income countries (e.g. Europe and North America) that is sent for recycling, 80% ends up being shipped (often illegally) to low and middle income countries such as China, India, Ghana, Nigeria, and many countries in Latin America for recycling, although in some of the countries (e.g. China and India), the proportion of electronic products manufactured domestically is increasing rapidly (4,6,7,9–12).

Such a globalized and often illegal importation of e-waste has adverse ecological and health implications on both e-waste workers and the general population as well as the environment in the receiving countries (3,13–21). For instance, exposure to environmental contaminants arising from e-waste processing activities is a worldwide problem which affects many countries and regions especially China, India, southeast Asia, sub-Sahara Africa, and Latin American countries (22–37). Studies conducted in the different regions of the world have reported a link between e-waste processing activities and health outcomes, especially physical injuries (3,10). The dispersal of toxic particles released by open-air burning of e-waste across the Pearl River Delta region alone, which is home to 45 million people, has been reported in southeast China and globally; the exposed population may exceed 200 million people (3,10).

The Ghanaian exposure situation reflects the global context as a recent joint report by the Green Cross (Switzerland) and the Blacksmith Institute (United States) has ranked Agbogbloshie, Ghana among the top 10 most polluted places in the world (8,38). However, unlike the decentralized e-waste recycling sites in China, India, and Uruguay, the Agbogbloshie e-waste dump site is more centralized and characterized by copious toxic fumes emanating from the e-waste burning process which provides income for some of world's poorest people. For decades, Agbloboshie has been the dumping ground for electronic products imported into Ghana, from mainly North America and western Europe. A report of Ghana's Environmental Protection Agency (Ghana-EPA) puts the annual importation amount at about 215,000 tons of second-hand consumer items, which result in 129,000 tons of e-waste per year, which is expected to double by 2020 (8,38). With the lack of proper recycling facilities in country at the moment, the bulk of this e-waste will continue to be recycled through dismantling, acid-leaching, and burning (1,8,10,38). At this dump site, Styrofoam food containers and car tires are often added as fuel to sustain the burning process by local recyclers: a recycling process which releases huge quantities of toxic materials, including lead and mercury into the ambient environment (1,10,14,39). As well as being the location of one of Accra's largest food markets, some 40,000 people are said to live in the wider area and it is therefore believed that some 250,000 people are likely to be exposed to the fumes released during the e-waste recycling activities (1,10,14,17,40). While there is a lack of reliable data on e-waste workers' knowledge of the potential hazards associated with their work, no studies have been conducted on the livelihood alternatives that the e-waste workers at Agbogbloshie would prefer if they were given the opportunity. This lack of information poses a challenge to institutions and agencies wishing to address the e-waste pollution problem through intervention programs. This study therefore sought to address the current dearth of information on e-waste workers' knowledge about the potential hazards associated with their work and the livelihood alternatives to e-waste recycling. An analysis of their situation will help provide a clear understanding of safety issues to incorporate into health promotion and educational safety programs for the workers as well as social and/or environmental interventions to improve the health and well-being of the surrounding community.

Methods

Design and participants

A qualitative cross-sectional study was conducted during the months of May and June 2012 to gather empirical information on e-waste workers' knowledge about the potential hazards associated with their work and the livelihood alternatives to

e-waste recycling with a sample consisting of twenty all-male electronic waste workers at the Agbogbloshie scrap metal yard in Accra, Ghana. Subject/participant recruitment was conducted following an initial community sensitization process by first informing the chairman of the recyclers who in turn informed all the community members about the planned field research activities/field data collection exercise and the dates of planned visits. This study took advantage of the existing strong relationship between the research team and the community members. The research team has a long history of conducting research in the community which has ultimately led to the establishment of a formal partnership (aiming to reduce community exposure to environmental toxins associated with e-waste recycling activities in the area) between the research team and non-governmental organizations (NGOs), namely Green Advocacy and Blacksmith Institute on the one hand and the community members on the other hand. Under the recruitment criterion that workers had to have at least one year of continuous experience in e-waste processing, twenty e-waste workers, who specialized in different specific work capacities (e.g. scavenger, dismantler, and/or burner), were approached and randomly selected to participate in the study. Consent forms were read and explained, and e-waste workers willing to participate provided consent. Research ethics approval was obtained from the Ghana Health Service Ethical Review Board.

Data were collected through in-depth, open-ended interviews with the use of a semi-structured guide with questions related to the study objectives. All interviews were conducted and recorded in Dagbani, the predominant language of the northern region of Ghana. The interviews, lasting 25–30 mins on average, were conducted in person by two male experienced interviewers who were native Dagomba, fluent in both Dagbani and English, with one participant at a time in a secluded environment so as to avoid interruptions by other people.

The interviews focused on the health hazards that the e-waste workers encountered, or believed that they themselves or others in the area encountered as a result of e-waste recycling activities. Information was also collected on the livelihood alternatives that the e-waste workers would prefer if authorities were contemplating social and/or environmental interventions. Theme saturation—a point where new data collected no longer brought additional insights to the stated objectives—was reached after the twentieth in-depth interview. At this point the interviews were discontinued as previously published (10). All interviews were audio-recorded and field notes were taken.

Analysis

The two experienced interviewers separately transcribed and translated verbatim all the interviews into English in a word processing program. In a situation where there was no consensus, the interviewers reviewed the transcriptions and the original recordings until consensus was reached. The transcripts and expanded notes were stored as electronic files and coded manually for textual analysis to gather empirical evidence on e-waste recyclers' knowledge about health risks associated with e-waste recycling activities (41,42). As required in qualitative thematic analysis (41–43), the coding process involved identifying major themes and subthemes in each of the transcripts. The identified themes, or concepts, were then compared across the transcripts to determine differences and similarities in the participants' knowledge about the hazards associated with their work as well as their preferred livelihood alternatives if given the opportunity. The themes were interpreted in the context of extant literature in a meaningful way to reach conclusions without attempting to generate a theory since our interest was in gathering empirical evidence to guide health promotion activities among e-waste workers and to inform health policy reforms.

Findings

Participants' characteristics

As previously published (10), a total of 20 e-waste workers took part in the study. All participants were male, between the age of 13 and 34 years, with the majority in their twenties. All participants were from the northern region of Ghana and belonged to the Dagomba ethnic group. Of the 20 participants, five had a junior high school education, five had no formal education, and the rest had received some level of primary education. There were three distinctive e-waste processing roles: (1) scavengers, who engaged in electronic wastes and metal scrap

collection; (2) dismantlers, who engaged in manual separation of e-waste components/metal scrap; and (3) burners, who used open-fires to burn away components that could not be manually removed by the dismantlers (10). Seven of the participants were scavengers, seven were dismantlers, and six were burners.

Knowledge and awareness of potential health hazards

Knowledge and awareness of the hazards associated with informal e-waste processing among the workers was low. This was illustrated in various ways, and we present these ways in detail below.

Views about personal health problems

Participants reported experiencing various health issues within the past year: eye pains, body pains, catarrh, fever, hemorrhages, coughs, and abdominal pain. However, the majority of the participants did not believe their work played any role in these symptoms. Symptoms like coughing, fever, and abdominal pain were described as experienced by them and observed in others who did not work in e-waste processing. In addition, participants reported that such symptoms affected them even before they entered the e-waste recycling occupation. As recounted by one participant:

> I was sick of [sic] catarrh in the year. It gave me headache and blocked my nostrils; I can't tell whether this sickness is as a result of my job because even when I am not doing this job, while in the north I still occasionally experience the same health problems.

In addition, a few of the participants reported suffering from fever (which they equated to malaria) during the past year and erroneously attributed the cause to the scorching sun and the heat from the burning process. As stated by one participant: "This year I was seriously sick of [sic] malaria which I think was partly caused by the heat I experience while burning electronic wastes."

Participants were able to correctly identify a limited number of health problems due to their work, specifically eye pains and physical injuries like cuts and burns. As stated by one participant: "This year I had occasional eye pains especially when I bend [sic] down just after burning." Another described how one could get injured in the dismantling component of e-waste processing: "You would [sic] get injured when you are hitting the computer to dismantle it. This is especially so when you are not well versed in how to do the dismantling of the electronic waste." Some participants also acknowledged that smoke from the burning process was a potential health concern. One participant reported: "The smoke can go deep into your chest…" while another described that the smoke can "… enter inside your eyes and make it [sic] red-looking."

It was observed that a few participants were informed about the dangers of e-waste processing and how the job could lead to potential health problems by city authorities and environmental advocacy groups; however, they did not know the specifics nor did they observe it amongst their co-workers. As described by one individual: "The whites have been frequenting this place in the last 3 years to tell us that our job can cause health problems but we are yet to see these problems." Another stated: "I heard this work may lead to some sicknesses, but I do not know the specific sicknesses."

Views about community health

Most of the workers involved in the burning process of e-waste recycling believed that the smoke from the burning process was a health hazard associated with their work; however, they did not believe the smoke had any health implications for the people living and working around them. "I can't tell if my job affects the health of other people in the market who do not do the same electronic waste job." According to participants, the smoke was largely a nuisance to people, specifically to the nearby companies. The neighboring companies would often complain and when that happened, the burners would reschedule the large-scale burning activities for the evenings, after the companies had closed for the day. "Our work doesn't disturb people so it is only the companies around that complain. When they do, we try to reserve the large-scale burning activities for the evening or night after those companies close."

Participants who were scavengers and dismantlers did not believe that their work harmed anyone in the community, except for the occasional injuries that may be caused if someone walked too close to

their work: "When I drop the waste, somebody can step on it and get injured."

Sources of treatment

Participants explained that when they were ill, they would attempt to 'self-cure' first. Many reportedly used herbal remedies to cope with the symptoms: "On the few occasions I suffered stomach ache, I just smoked 'wee' and became fine." When herbal remedies failed, participants reported that they would go to the drugstore and speak with the pharmacist about their health problems to obtain medications, for they are a cheaper option than going to see a doctor. As told by one participant: "I don't go to hospital when I am sick, I only buy medicine… my friends help me with money to buy medicine and I use my own money when I have [sic]." Generally, medications were reported to help; however, in some extreme cases, hospitalization was necessary: "One of our brothers got sick and had to be sent to Korle Bu hospital and later northern region [sic]. He reduced drastically in weight and according to the hospital his body had lost some water."

Views on work environment

The participants described their work environment as "disturbing" and "dirty." The site was observed to be littered with rubbish, with piles of e-waste materials waiting to be burned or dismantled. The ground was a mixture of dirt, broken glass, rubbish, and pieces of half-embedded materials such as computer monitors.

Amongst the participants, there were mixed opinions on the conditions of the work environment. Some participants argued that they would like to keep the area the way it was to avoid losing the space. As illustrated by one participant: "We want our working place to remain dirty because if it becomes clean other workers in this market will locate their containers here. That means our working place would be taken over." Others wanted a cleaner environment and tried to advocate for it, reportedly through "talks on how to make the environment clean" or "contributing some money to get this place cleaner." One participant even stated that "as the rubbish around disturb [sic] … we burn them in the evening" to help keep the work environment clear of rubbish.

Personal protective measures

All participants reported little to no usage of personal protection equipment (PPE). Many burners reportedly wore safety shoes to protect themselves from burns: "I don't use anything to protect myself…. I only use shoes when burning to protect my leg [sic] from the fire." Interviewees who did not participate in the burning process stated that they would protect themselves from the smoke by avoiding the area or sometimes they used a piece of cloth to cover their mouth and nose. One participant who was a dismantler stated:

> I use heavy shoes to protect me [sic] from cuts in my legs. I don't use gloves, but what I do is [sic] I don't get close to where they do the burning and in case am passing by I use a duster to cover my face, nose, and eyes.

Another participant who was a scavenger reported that "After going to the bush to buy computers, I leave my truck and rush to the house so that I don't inhale the smoke… I protect myself from the smoke by making sure I don't stand close to it."

A few participants stated that they used gloves sometimes to protect against cuts and burns. Many of the participants occasionally reported using mask-like materials such as dusters or banners to cover their faces. Some reported being provided with face masks; however, these were rarely used. "We are not able to continuously use nose masks because the sweat easily spoils it [sic]."

Preferred livelihood alternatives

All participants stated their desire to eventually find another job that would provide a more sustainable source of income. They described the e-waste business as difficult work with no viable future. The following statement represents what many interviewees reported: "I don't foresee doing this work for the rest of my life because I think this work has no future for me." One reason why the e-waste business was viewed by workers to be unsustainable was the irregular income: "Our challenge is making the money… we are not usually able to save, we just work to feed ourselves." Another reason was the lack of skills that one could gain:

"This work does not give any skill. Although money is important, it is useless if a job does not improve your skill but only gives you money." Another participant similarly stated: "I will [sic] like to change my job because this job is not job [sic]; this is just business, not handwork or skill."

When asked about the type of employment they would like to do, participants mentioned various fields: transportation, agriculture, hospitality, and services. Specifically, participants mentioned occupations in professional driving, butchering, tailoring, auto mechanics, carpentry, retail, and farming. One participant stated his desire to go back to school: "I intend to get enough money to go back to school; that is why I am doing this job." Despite the strong interest to seek other job opportunities, there were financial constraints that prevented them from being able to leave and learn another trade/skill to apply to future occupations. One participant stated:

> I prefer to leave this job and become a tailor. I don't think so much about contact [sic] people to learn from, like one particular tailor in Konkomba market, because I need to get the money first through the burning of electronics.

The e-waste business served as an avenue for workers to save and raise capital towards another occupation.

The locations of these desired job opportunities were also investigated. All participants wanted to be employed in the northern region of Ghana. The main reason for wanting to return to the northern region was that they wanted to be close to their families. As explained by one participant: "If anybody decides to help me I would prefer he helps me do a job that would not leave me far from my parents in the north."

Discussion

The various health symptoms that were reported by participants are consistent with a recent study conducted in Brazil (44–48) that noted a high frequency of occupational health issues such as cuts and body pain amongst informal workers (41,42,47,49). Another study conducted on scrap metal cutters reported coughs and rhinitis as the main health issues of the workers (18,21,41,42,47,50,51). Therefore, our study provides further evidence that symptoms such as cuts, body pain, coughs, and catarrh are frequent among scrap metal workers, including those involved with e-waste recycling. However minor they may seem, these symptoms are suggestive of greater health concerns and/or can lead to long-term health complications as well as chronic lung disease and cancer (3,18,21,42,47,50). For example, body pain may be an indicator of poor ergonomic health and without proper interventions may lead to various musculoskeletal disorders and increase one's risk of permanent musculoskeletal damages (47,51). Workers did not view the e-waste processing business to have an impact on the health of the nearby community, other than the description of how the smoke may be bothersome to nearby companies, although the smoke from the burning process may contain toxic dioxins and furans (13–15,17,49) as well as oxides of heavy metals such as copper, aluminum, and cadmium (18,39,51)—all of which could cause serious health impacts on the workers and the surrounding community (3,5,10,13,21).

While low educational attainment may partly explain the limited knowledge and misconceptions about health conditions associated with recycling work as well as the general poor perception of health risks among the e-waste workers, perhaps the pervasive poverty and low or lack of skills to guarantee alternate gainful employment appear to be a more reasonable explanation of e-waste workers' decision to sustain the recycling business despite the health risks associated with it (52,53). This assertion seems plausible in view of the fact that the e-waste recyclers did not view the e-waste business as a long-term employment option, claiming the work was difficult and did not provide a sustainable source of income (3,7,54,55). The e-waste workers are migrants escaping poverty from northern Ghana to the southern coastal cities which are relatively more developed and are therefore perceived to offer better livelihood opportunities (54–58). However, the migrants lack employable skills that guarantee a meaningful livelihood and the quest for survival forces them into the e-waste recycling which requires little or no skills and since the recycling activities have implications for survival and are the only way to guarantee their livelihood, they tend to discount any health concerns in favor of the income generated from the recycling business (53,57,58).

The limited use or non-use of PPE at informal electronic waste processing sites appears to be related to the low perception of health risks among the workers, and this finding is consistent with previous studies (4,9,10,13,14). While these findings may be helpful in understanding the personal health among e-waste workers, further analytical studies will provide better understanding of long-term cumulative exposures on the workers' health and indeed, such epidemiological studies are currently underway by our research group.

Conclusions

Informal electronic waste processing is a hazardous occupation that threatens the safety and well-being of workers, including the surrounding community. Generally, the workers did not perceive their work process and work environment in a positive light and might be amendable to informed decision-making on worker health with an increase in education and awareness creation about environmental pollution and the health risks associated with informal e-waste recycling. By becoming more knowledgeable and aware of the health and environmental impacts of e-waste processing, as well as the options available to improve the situation, workers can then collaborate and work toward creating a safe and healthy work environment. However, education and awareness creation alone may not bring about a reasonable and acceptable behavioral change among the e-waste workers. Therefore, agencies or organizations that are interested in implementing social intervention programs aimed at improving the livelihoods of workers should not only consider sustainable technologies to improve the safety and well-being of the workers, but should also provide opportunities for environmental and public health action, which engages and involves the e-waste workers directly in decision-making with support to learn other trades, training, and upgrade of skills appropriate for carrying out more environmentally sustainable recycling activities.

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Conflict of interest

None declared.

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References

1. Ghana e-waste country assessment: SBC e-waste Africa project (database on the Internet). GreenAd-Empa, 2011. Available from: http://ewasteguide.info/files/Amoyaw-Osei_2011_GreenAd-Empa.pdf (accessed July 13, 2012).
2. Feldt T, Fobil JN, Wittsiepe J, Wilhelm M, Till H, Zoufaly A, et al. High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana. Sci Total Environ. 2014; 466–467: 369–376.
3. Grant K, Goldizen FC, Sly PD, Brune M-N, Neira M, van den Berg M, et al. Health consequences of exposure to e-waste: a systematic review. Lancet Global Health. 2013; 1: e350–361.
4. Julander A, Lundgren L, Skare L, Grandér M, Palm B, Vahter M, et al. Formal recycling of e-waste leads to increased exposure to toxic metals: an occupational exposure study from Sweden. Environ Internat. 2014; 73: 243–251.
5. Perkins DN, Brune Drisse M-N, Nxele T, Sly PD. E-waste: a global hazard. Annals Global Health. 2014; 80: 286–295.
6. Electronic waste—time to take stock. Lancet. 2013; 381: 2223.
7. Lundgren K. The global impact of e-waste: addressing the challenge, 2012. Available from: http://www.ilo.org/wcmsp5/groups/public/@ed_dialogue/@sector/documents/publication/wcms_196105.pdf (accessed 10 October 2014).
8. Blacksmith Institute, Green Cross, GAHP. Top Ten Countries Turning the Corner on Toxic Pollution. New York City and Zurich: Blacksmith Institute and Green Cross; 2014.
9. Zeng X, Song Q, Li J, Yuan W, Duan H, Liu L. Solving e-waste problem using an integrated mobile recycling plant. J Cleaner Production. 2015; 90: 55–59.
10. Akormedi M, Asampong E, Fobil JN. Working conditions and environmental exposures among electronic waste workers in Ghana. Intern J Occupational Environ Health. 2013; 19: 278–286.
11. Berwick DM, Hackbarth AD. Eliminating waste in US health care. JAMA. 2012; 307: 1513–1516.
12. Gabel DA. E-waste dump in Africa contaminating community. Global pollution and prevention news (serial on the Internet), 2011. Available from: www.enn.com/pollution/article/43495 (accessed November 1, 2011).
13. Song Q, Li J. A review on human health consequences of metals exposure to e-waste in China. Environ Pollution. 2015; 196: 450–461.

14. Feldt T, Fobil JN, Wittsiepe J, Wilhelm M, Till H, Zoufaly A, et al. High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana. Sci Total Environ. 2014; 466–467: 369–376.
15. Al-Saleh I, Alsabbahe A, Shinwari N, Billedo G, Mashhour A, Al-Sarraj Y, et al. Polycyclic aromatic hydrocarbons (PAHs) as determinants of various anthropometric measures of birth outcome. Sci Total Environ. 2013; 444: 565–578.
16. Hogarh JN, Seike N, Kobara Y, Habib A, Nam J-J, Lee J-S, et al. Passive air monitoring of PCBs and PCNs across east Asia: a comprehensive congener evaluation for source characterization. Chemosphere. 2012; 86: 718–726.
17. Asante KA, Adu-Kumi S, Nakahiro K, Takahashi S, Isobe T, Sudaryanto A, et al. Human exposure to PCBs, PBDEs and HBCDs in Ghana: temporal variation, sources of exposure and estimation of daily intakes by infants. Environ Internat. 2011; 37: 921–928.
18. Wong MH, Wu SC, Deng WJ, Yu XZ, Luo Q, Leung AOW, et al. Export of toxic chemicals—a review of the case of uncontrolled electronic waste recycling. Environ Pollution. 2007; 149: 131–140.
19. Buratti M, Campo L, Fustinoni S, Cirla PE, Martinotti I, Cavallo D, et al. Urinary hydroxylated metabolites of polycyclic aromatic hydrocarbons as biomarkers of exposure in asphalt workers. Biomarkers. 2007; 12: 221–239.
20. Schmidt SW. Unfair trade e-waste in Africa. Environ Health Perspectives. 2006; 114: 232–235.
21. Allsopp M, Santillo D, Johnston P. Environmental and human health concerns in processing electrical and electronic wastes. Contract no.: GRL-TN-04–2006, 2006. Exeter: University of Exeter.
22. Zheng J, Yan X, Chen SJ, Peng XW, Hu GC, Chen KH, et al. Polychlorinated biphenyls in human hair at an e-waste site in China: composition profiles and chiral signatures in comparison to dust. Environ International. 2013; 54: 128–133.
23. Zheng J, Chen KH, Yan X, Chen SJ, Hu GC, Peng XW, et al. Heavy metals in food, house dust, and water from an e-waste recycling area in south China and the potential risk to human health. Ecotoxicology Environ Safety. 2013; 96: 205–212.
24. Zhang HB, Luo YM, Teng Y, Wan HF. PCB contamination in soils of the Pearl River Delta, south China: levels, sources, and potential risks. Environ Sci Pollution Research. 2013; 20: 5150–5159.
25. Zeng YH, Luo XJ, Yu LH, Chen HS, Wu JP, Chen SJ, et al. Using compound-specific stable carbon isotope analysis to trace metabolism and trophic transfer of PCBs and PBDEs in fish from an e-waste site, south China. Environ Sci Tech. 2013; 47: 4062–4068.
26. Yang Y, Lu XS, Li DL, Yu YJ. Effects of environmental lead pollution on blood lead and sex hormone levels among occupationally exposed group in an e-waste dismantling area. Biomed Environ Sci. 2013; 26(6): 474–484.
27. Yang QY, Qiu XH, Li R, Liu SS, Li KQ, Wang FF, et al. Exposure to typical persistent organic pollutants from an electronic waste recycling site in northern China. Chemosphere. 2013; 91: 205–211.
28. Wang P, Zhang HD, Fu JJ, Li YM, Wang T, Wang YW, et al. Temporal trends of PCBs, PCDD/Fs and PBDEs in soils from an e-waste dismantling area in east China. Environ Sci Processes Impacts. 2013;15:1897–1903.
29. Shang HT, Wang P, Wang T, Wang YW, Zhang HD, Fu JJ, et al. Bioaccumulation of PCDD/Fs, PCBs and PBDEs by earthworms in field soils of an e-waste dismantling area in China. Environ Internat. 2013; 54: 50–58.
30. Offenhuber D, Wolf MI, Ratti C. Trash track-active location sensing for evaluating e-waste transportation. Waste Management Research. 2013; 31: 150–159.
31. Fu JJ, Zhang AQ, Wang T, Qu GB, Shao JJ, Yuan B, et al. Influence of e-waste dismantling and its regulations: temporal trend, spatial distribution of heavy metals in rice grains, and its potential health risk. Environ Sci Tech. 2013; 47: 7437–7445.
32. Song QB, Wang ZS, Li JH, Zeng XL. Life cycle assessment of TV sets in China: a case study of the impacts of CRT monitors. Waste Management. 2012; 32: 1926–1936.
33. Song QB, Wang ZS, Li JH, Duan HB. Sustainability evaluation of an e-waste treatment enterprise based on energy analysis in China. Ecological Engr. 2012; 42: 223–231.
34. Song QB, Wang ZS, Li JH. Residents' behaviors, attitudes, and willingness to pay for recycling e-waste in Macau. J Environ Management. 2012; 106: 8–16.
35. Smit W, Parnell S. Urban sustainability and human health: an African perspective. Current Opinion Environ Sustain. 2012; 4: 443–450.
36. Schluep M, Terekhova T, Manhart A, Muller E, Rochat D, Osibanjo O. Where are WEEE in Africa? In: 2012 Electronics Goes Green 2012+, Berlin, Germany, September 9–12, 2012.
37. Saavedra YMB, Ometto AR. E-waste in the Brazilian context. In: 2012 Electronics Goes Green 2012+, Berlin, Germany, September 9–12, 2012.
38. Blacksmith Institute, Green Cross, GAHP. The World's Worst 2013: The Top Ten Toxic Threats, Cleanup, Progress, and Ongoing Challenges. New York City and Zurich: Blacksmith Institute and Green Cross; 2013.
39. Asante KA, Agusa T, Biney CA, Agyekum WA, Bello M, Otsuka M, et al. Multi-trace element levels and arsenic speciation in urine of e-waste recycling workers from Agbogbloshie, Accra in Ghana. Sci Total Environ. 2012; 424: 63–73.
40. Robinson BH. E-waste: an assessment of global production and environmental impacts. Sci Total Environ. 2009; 408: 183–191.
41. Braun V, Clarke E. Using thematic analysis in psychology. Qualitative Research Psych. 2006; 3: 77–101.

42. Fereday J, Muir-Cochrane E. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. Internat J Qual Methods. 2006; 5: 80–92.
43. Attride-Stirling J. Thematic networks: an analytic tool for qualitative research. Qual Research. 2001; 1: 385–405.
44. Binion E, Gutberlet J. The effects of handling solid waste on the wellbeing of informal and organized recyclers: a review of the literature. Internat J Occupational Environ Health. 2012; 18: 43–52.
45. Binion ENO. The Perception of Health with Informal Recyclers in Buenos Aires, Argentina. Master's Thesis, University of Victoria, Canada, 2012.
46. Bishop A. High toxins at school near e-waste recycling site. Pollution (serial on the Internet), 2011. Available from: http://www.earthtimes.org/pollution/high-toxins-school-waste-recycling-site/1566/ (accessed 10 October 2014).
47. Gutberlet J. Wasting health. In: Gutberlet J (eds) Recovering Resources—Recycling Citizenship: Urban Poverty Reduction in Latin America. Aldershot: Ashgate Publishing; 2008, p. 212.
48. Huo X, Peng L, Xu X, Zheng L, Qiu B, Qi Z, et al. Elevated blood lead levels of children in Guiyu, an electronic waste recycling town in China. Environ Health Perspectives. 2007; 115: 1113–1117.
49. Wong MH, Wu SC, Deng WJ, Yu XZ, Luo Q, Leung AOW, et al. Export of toxic chemicals—a review of the case of uncontrolled electronic-waste recycling. Environ Pollution. 2006; 149: 131–140.
50. Parizeau KM. Urban Dirty Work: Labour Strategies, Environmental Health, and Coping among Informal Recyclers in Buenos Aires, Argentina, PhD Thesis, University of Toronto, Canada, 2011.
51. Porta D, Milani S, Lazzarino AI, Perucci CA, Forastiere F. Systematic review of epidemiological studies on health effects associated with management of solid waste. Environ Health. 2009; 8: 14.
52. Oberhauser AM, Yeboah MA. Heavy burdens: gendered livelihood strategies of porters in Accra, Ghana. Singapore J Tropical Geography. 2011; 32: 22–37.
53. Oberhauser AM, Hanson KT. Negotiating livelihoods and scale in the context of neoliberal globalization: perspectives from Accra, Ghana. African Geographical Review. 2007; 26: 11–36.
54. Siegrist J, Benach J, McKnight A, Goldblatt P, Muntaner C. Employment Arrangements, Work Conditions and Health Inequalities. Duesseldorf: University of Duesseldorf; 2011.
55. Prakash S, Manhart A. Socio-economic Assessment and Feasibility Study on Sustainable E-waste Management in Ghana. Report, 2010. Freiburg: Freiburg Head Office.
56. Tucker P, Folkard S. Working time, health and safety: a research synthesis paper, 2012. Available from: http://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—travail/documents/publication/wcms_181673.pdf (accessed 10 October 2014).
57. Wilson DC, Velis C, Cheeseman C. Role of informal sector recycling in waste management in developing countries. Habitat Internat. 2006; 30: 797–808.
58. Yeboah MA, Appiah-Yeboah K. An examination of the cultural and socio-economic profiles of porters in Accra, Ghana. Nordic J African Studies. 2009; 18: 1–21.