Women's Health in Agbogbloshie and Teacher Mante

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I. Introduction

On an e-waste site, women are often overlooked and underrepresented - their struggles, hardships, and achievements are often minimized and undocumented. This issue is prevalent, especially for women in Sub-Saharan Africa and Latin America, who live so close to material processing. The long-term health impacts of interacting with waste sites are severe and potentially life-threatening, though little relevant research has been published. There is less information tailored to women than to men, meaning research into women's health is scarce and women's issues are difficult to solve. In an attempt to increase women's visibility on e-waste sites, this project seeks to bring attention to women's health living on e-waste sites.

Workers on an e-waste site are exposed to many health risks posed by the conditions of their workplace. These risks can come from the materials they work with, as well as the physical exertion caused by their labor. Some of the most significant health risks posed by e-waste sites are the toxins released into the environment by e-waste. These toxins can include heavy metals like lead, as well as contaminants known as dioxins. Waste sites are known to cause reproductive harm, cancer, and respiratory issues specifically in women. These dangers are intensified for pregnant women, who could transmit the toxins to their unborn children. Babies born and exposed to a waste site could experience birth defects, low birth weight, stillbirths, and preterm birth, among many other m
ental and cognitive problems that could develop in the long term (Johnson 2021).

There is a lack of awareness of the long-term health impacts posed by e-waste, and "when people fail to be alarmed about a risk or hazard, they do not take precautions" (Weber, 2006). In our meeting with a woman working at Agbogbloshie, she did not mention long-term contamination from waste when describing her health concerns with her work on the site. This issue requires attention because awareness of contamination is instrumental in preventing its health detriments. Women's duties in food preparation and child care emphasize the necessity of their lessening the risk of contamination. This project involved working with women living on the Agbogbloshie site to communicate the risks posed by e-waste.

Meetings with Ghanaian partners necessitated a shift in the focus of the project from the communication of solutions to pollution in e-waste communities to raising general awareness of pollution. Our partners did not communicate any understanding of the pollution in their communities, which highlighted a problem with the focus of the project: solutions to unknown problems may not be effective, so "interventions need to raise awareness rather than prescribe protective actions to be culturally compatible with the resourcefulness of rural individuals" (Larsson et al., 2006). To ensure co-design, this project compares the needs of its partners with secondary research and implements a universally-understandable presentation to communicate the dangers of waste living. This allows people on e-waste sites to make decisions and work

towards benefitting their long-term health. Women will particularly benefit, as much of the information in this project focuses on them and their children's health, and their traditional roles on the site are discussed the most. Once the danger has been properly communicated, future work and projects with our Ghanian partners could then delve into looking at possible solutions to mitigating the effect of contaminants and pollutants from e-waste sites.

To convey the process through which this project was co-designed, this chapter will discuss issues with e-waste and potential solutions. Beginning with describing the site on which our partners live and their routines, the chapter contextualizes the health risks posed by long-term exposure to an e-waste site. The further background focuses on methods and materials of exposure and how pollutants affect women and the people around them. This leads to possible solutions to these issues and a summary of the background information. Once the background has been established, the methods for the execution of the project are detailed. This involves describing the research that makes up much of the background, as well as ideation with partners in Agbogbloshie. The information-gathering detailed here is examined and reported in the data and results section of the chapter, the makeup of which will be largely qualitative regarding the satisfaction of our community partners. This is then discussed in the following section, examining the impacts of the project and how generative justice is achieved. This is important in determining the long-term effectiveness of the project in helping people create success for themselves. The conclusion wraps up this chapter and lists possible avenues for further research. This chapter is not a completion of this study, it provides a point from which further projects can begin and apply this research.

II. Background and Literature Review

Electronic waste, or e-waste, "is… any end-of-life 'equipment which is dependent on electrical currents or electromagnetic fields in order to work properly"(Grant et al. 2013). The modern rise of consumerism has led to a congruent rise in e-waste worldwide (Grant et al. 2013). There are multiple sectors of e-waste, one is the informal sector which involves dismantling electronics "to retrieve valuable elements with primitive techniques, without or with very little technology to minimize exposure or protective equipment, allowing the emission of dangerous chemicals" (Grant et al. 2013). Ghana is "one of the top five importers of e-waste in the world" and Agbogbloshie is "one of the most intensive e-waste scrapyards in the world" (Sovacool 2019).

A. About Agbogbloshie

This project focuses on Ghanaian e-waste sites, namely Agbogbloshie in Accra. This site is located next to a river and houses many people. An e-waste site serves as a workplace for many, as well as a home. This makes places like Agbogbloshie bustle with the energy of a city

with vendors selling food and water to those processing the waste alongside those growing food and tending to livestock. Close contact among different aspects of life on an e-waste site is inevitable when animals graze alongside a wire stripping operation.

Agbogbloshie is situated next to a river providing non-potable water for numerous applications. Animals on e-waste sites are usually free-range, meaning they are not relegated to cages and roam the area freely. Their exposure to e-waste is difficult to curb when they have full agency over their movement. “The Agbogbloshie market situated by the main road is only a few meters from the burn site and is forever thrumming with customers buying tomatoes, onions, and yams — food that could be contaminated” (Lawal 2019). Contamination is likely to increase with proximity to e-waste, but this is not likely to change with the move to Teacher Mante. Agbogbloshie does not suffice for the opportunity e-waste creates in Ghana, and another site is developing nearby, Teacher Mante. For both of these sites, drone footage has been obtained to show the lay of the land. Teacher Mante is a large open green space without a nearby body of water.

Figure 1: Picture of the Agbogbloshie E-Waste Site

Figure 2: Aerial Picture of the Teacher Mante E-Waste Site

While most women do not work directly with e-waste, they operate as merchants in close proximity. “Thousands of women work here and live in Old Fadama, a nearby slum. Many of them sell food to the scrap dealers, and in the process unknowingly expose themselves to toxicants from dismantled electronics” (Lawal 2019). They are often exposed to air pollution like smoke from burning plastics or dust-containing toxins. Contact can also occur through the goods they sell with close contact to e-waste being unavoidable.

The workers on the site are typically “from low-income families and say they do not have any other means of survival. Many are from Tamale, in the Northern Region, where ‘we don’t get any jobs,’ says 37-year old Yusuf Ibrahim, a scrap dealer who has worked in Agbogbloshie for over a decade” (Lawal 2019). E-waste sites are highly competitive because of the opportunity they provide. Jobs are not plentiful in other environments, so despite the difficult conditions, many lower-income families find themselves here as they can't afford to risk relocating and finding employment elsewhere.

B. Sources and Pathways of E-waste Pollution

To solve the issues contaminants pose on e-waste sites, one must first identify the sources from which they arise. These sites contain many sources for contamination through the waste processed there, and many avenues for pollution. Some of the most dangerous contaminants from e-waste are dioxins and heavy metals, both of which can enter the environment through the most common methods of e-waste processing. Once in the environment, there are many

pathways to contamination. Identifying the most common and harmful pathways will be instrumental in helping people avoid adverse health effects.

1. Materials and Pollution Pathways

Before identifying the problems caused by e-waste, the sources of contaminants must be identified. Some of the most common sources of pollutants are batteries and wires. These resources are abundant in modern e-waste and contribute heavily to deposits of heavy metals and other toxins. Batteries often contain "Pb, Cd, Ni, manganese (Mn), and lithium (Li)", all of which are harmful if ingested (Kim, 2019). Exposure can occur due to groundwater leaching, in which liquid from the batteries containing these metals releases to rivers or is absorbed by the soil in which food crops are grown and on which livestock are raised (Sovacool, 2019). Wires and other electronic scraps also threaten the health of residents of e-waste sites because of the plastic they release when burned or stripped. This is especially worrying because "children and pregnant women, the most vulnerable groups, also take part in sorting plastic chips and removing the plastic coating from wires" (Chan and Wong, 2013). E-waste is dangerous to the community, since "numerous studies have described various informal e-waste recycling techniques, including open burning of printed circuit boards and cables" (Song and Li, 2014). This technique is also commonly used to remove the plastic coating from wires in bulk. Not only are workers directly involved with waste processing at risk of exposure, but food contamination affects all residents of an e-waste site. The pathways to exposure to this contamination must be understood for a solution to be modeled.

Pollution primarily enters residents' bodies through food, water, and air contamination. Through the air, contaminants commonly reach people by smoke or dust ingestion, often through inhalation. It has been found "in India, e-waste burning contribute[s] to severe air pollution, potentially explaining alarming levels of heavy metals in adult residents, which [are] associated with increased prevalence of cardiovascular morbidity, specifically hypertension" (Parvez, 2021). This research likely has application in Ghanaian e-waste sites due to the common practice of burning electronics to isolate the valuable metals from the plastics and other less useful components. Alongside polluted smoke, "exposure to the hazardous components of e-waste can occur through inhalation from the air, dietary intake, and soil/dust ingestion" (Song and Li, 2014). This dust poses a respiratory and dietary risk. It can contaminate the soil where crops are grown and animals are raised, and it can settle on food sold on or near the e-waste site. This dust can contain particles of heavy metals and plastic contamination which poses similar long-term health risks to smoke inhalation. Food, in particular, is a dangerous pathway for exposure, because the previous pathways "...can cause these pollutants from e-waste recycling to accumulate in the food chain and food-stuffs (i.e., fish from high trophic levels or lipid-rich tissues)" (Song and Li, 2014). The communal food preparation that is common on these sites means any problems one batch of food has will be introduced to all who eat from that batch. The numerous pathways to exposure present a challenge to those wishing to curb the health detriments caused by e-waste, forcing one to consider the issue from multiple angles and create

solutions that do not interfere with one another or the culture in which they are being implemented. Figure 3 below shows an example of how one pollutant, dioxins, can travel through many sources and end up harming the e-waste workers or inhabitants. This diagram shows that there is both direct and indirect exposure to toxins.

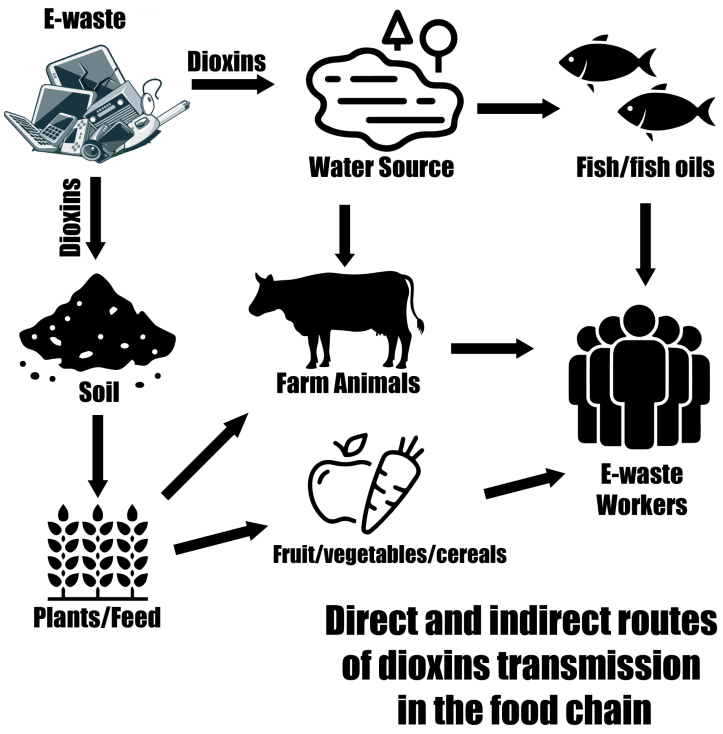

Figure 3: Diagram of Toxicant Pathways from E-Waste

C. How Different Pollutants Create Different Concerns

There are numerous pathways to the transmission of pollutants on an e-waste site. Different pathways and emissions can spread different pollutants and varying pollutants have different effects on the human body. Some prominent categories of pollutants noted by those studying e-waste sites include heavy metals, persistent organic pollutants, and others including dioxins, PCBs, PAHs, and Furans.

1. Heavy metals

Lead is a prominent heavy metal, with increased lead concentrations in cord blood and meconium correlating with significantly worse behavioral neurological assessment scores among women living in and around e-waste sites compared to elsewhere and could lead to the development of schizophrenia (Grant). Lead has also been linked to delayed puberty in girls and childhood exposures to “polychlorinated biphenyls, lead, mercury, and aluminum have led to changes in mental health -behavioral disturbances, attention deficits, hyperactivity, and conduct issues” (Grant).

For infants and newborns, “lead in blood was associated with a smaller head circumference, as well as a lower Ponderal Index” - a measurement used to determine human leanness as the ratio of height to body mass. High cadmium in blood was associated with lower birth weights, BMI, and Ponderal Index (Yu-Hsuan).

Overall, heavy metals are often associated with increased chances of cardiovascular morbidity, especially hypertension, as shown in research from Indian waste sites (Sovacool). Unfortunately, there is still a huge lack of research on the effect of heavy metals on pregnant women, so there could be many more adverse health effects currently unknown.

2. Persistent Organic Pollutants

Persistent organic pollutants are a class of pollutants that include “lipophilic, bioaccumulative substances. These are extremely resistant to breakdown because of long half-lives” (Grant), meaning people have a greater chance of coming into contact with them.

These persistent organic pollutants are especially dangerous to unborn children, with many adverse birth outcomes associated with increased exposures to these pollutants, such as polycyclic aromatic hydrocarbons, polybrominated diphenyl ethers, polychlorinated biphenyls, and perfluoroalkyls. Some of the tragic effects impacting births include spontaneous abortions, stillbirths, and premature births. Those that are born are reported to have birth weights and lengths well below normal.

Additionally, polychlorinated biphenyls, TCDD, and perfluoroalkyls decrease sperm quality as well as female fertility. These organic pollutants are also endocrine disruptors. They have a much stronger effect especially due to long-term exposure and accumulation - a danger for families and children raised on e-waste sites.

3. Other pollutants

For pregnant women, high PCB and PBDE levels were shown to be associated “with thyroid-stimulating hormone and total thyroxine”. Abnormal levels of these would cause drastic changes in weight, body temperature, and muscle strength.

All of these pollutants contribute to health detriments, especially for pregnant women and young children growing up with constant exposure. They have been associated with “reduced neonatal behavioral neurological scores, increased rates of attention-deficit/hyperactivity disorder, behavioral problems, changes in child temperament, sensory integration difficulties, and reduced cognitive and language scores”.

Lung and respiratory functions are disrupted, DNA could be damaged, and thyroid functions impaired from contamination. There is also an increased risk of some life-long chronic diseases. “[A] child who eats just one chicken egg from Agbogbloshie…will absorb 220 times the European Food Safety Authority daily limit for intake of chlorinated dioxins” (Johnson). Throughout a person's lifetime, this exposure to toxins can have serious health effects.

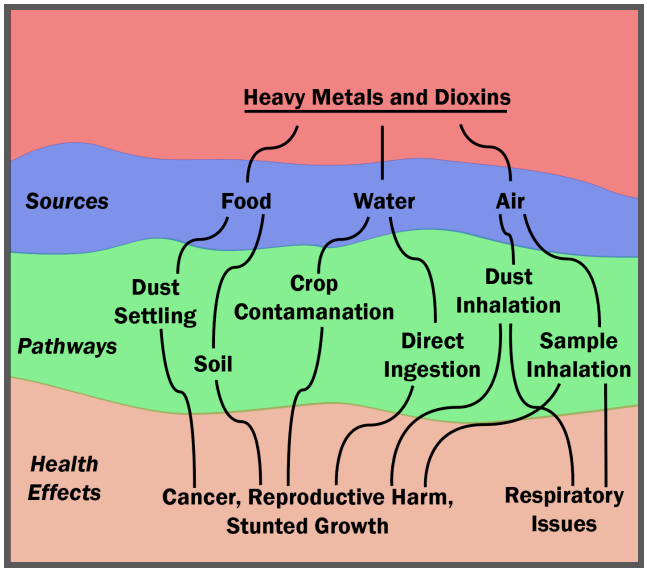

Figure 4: Sources and Pathways for Adverse E-Waste Health Effects

D. Effects of E-Waste Pollutants on Women's Health

E-waste pollutants have unique effects on women due to their constant exposure and close contact with the site: "women are also, particularly at risk to environmental hazards throughout the site" (Sovacool). This stems from a deeper social issue of class with women making up the lower classes. The dangerous and undesirable jobs women, therefore, take directly expose them to the pollutants of the site, and they have little social capital to use in making a change. "E-waste specifically affects women's morbidity/mortality, and fertility, as well as the health of any children"(Women). More than half of the pollutant chemicals found at e-waste sites have a direct effect on women's endocrine and reproductive systems. "12.9 million women are working in the informal waste sector, which potentially exposes them to toxic e-waste and puts them and their unborn children at risk"(Soaring). In addition to these concerns for women, "18 million children and adolescents, some as young as 5 years of age, are actively engaged in the informal industrial sector, of which waste processing is a sub-sector" (Soaring 2014). The main concerns for women's health on the e-waste site can be broken down into three main categories, reproductive harm, cancer, and respiratory issues.

1. Reproductive harm

Women working in E-waste sites often encounter fertility problems due to constant exposure to harmful chemicals. Women and their children/fetuses have many unique exposure pathways like "breastfeeding and placental exposures", "high-risk behaviors (eg, hand-to-mouth activities in early years and high risk-taking behaviors in adolescence), and their changing physiology (eg, high intakes of air, water, and food, and low rates of toxin elimination)"(Grant). Studies have shown that there are "consistent effects of exposure with increases in spontaneous abortions, stillbirths, and premature births, and reduced birthweights and birth lengths in most studies"(Grant). The fetus is most at risk during the early stages of the pregnancy. "Lead and

mercury exposure within the first trimester of pregnancy may affect fetal development, resulting in potential neurobehavioral development problems, low birth weight, or spontaneous abortion and birth defects" (Women). Fetuses are also most vulnerable to dioxin, one of the highly toxic by-products of E-waste. "Newborn[s], with rapidly developing organ systems, may also be more vulnerable to certain effects. Some people or groups of people may be exposed to higher levels of dioxins because of their diet (such as high consumers of fish in certain parts of the world) or their occupation (such as workers in the pulp and paper industry, in incineration plants, and at hazardous waste sites)"(World Health Organization). "Despite different exposure settings and toxicants assessed, there have been consistent effects of exposure with increases in spontaneous abortions, stillbirths, and premature births, and reduced birthweights and birth lengths in most studies. Adverse birth outcomes have been associated with increased exposures to polycyclic aromatic hydrocarbons and persistent organic pollutants, including polybrominated diphenyl ethers, polychlorinated biphenyls, and perfluoroalkyls. The main exception to these effects is the lack of association between exposures to metals and adverse birth outcomes"(Grant).

2. Cancer

In addition to causing reproductive harm, a build-up of dioxins and other pollutants are linked to various forms of cancer. "Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer" (Soaring). "The human body burden of e-waste exposure could cause all kinds of diseases—e.g. cancers, mental health and neurodevelopment disorders, thyroid dysfunction, and general physical health deterioration (DNA damage and effects on gene expression)"(Song). The "persistent organic pollutants [from E-waste] are a group of lipophilic, bioaccumulative substances that are very resistant to breakdown because of long half-lives. Common persistent organic pollutants found in electrical and electronic equipment components include brominated flame retardants (polybrominated diphenyl ethers), polybrominated diphenyls, dibrominated diphenyl ethers, polychlorinated biphenyls, polychlorinated or polybrominated dioxins, and dibenzofurans dioxins, hexabromocyclododecanes, and perfluoroalkyls."(Grant)

"Chronic exposure of animals to dioxins has resulted in several types of cancer. TCDD was evaluated by the WHO's International Agency for Research on Cancer (IARC) in 1997 and 2012. Based on animal data and human epidemiology data, TCDD was classified by IARC as a "known human carcinogen". However, TCDD does not affect genetic material and there is a level of exposure below which cancer risk would be negligible"(Grant). "Increase in polycyclic aromatic hydrocarbons (PAHs) pollution in the environment has been of great concerns." These PAHs "...are known to pose health problems including various forms of cancers in humans" (Asamoah). These toxins also affect children at an increased rate. "A report by the Cancer Control Division of the Ghana Health Service indicates a rise in the number of cancer cases and young people are in the majority" (Asamoah).

3. Respiratory issues

Air pollutants from the e-waste site are linked to a variety of respiratory and lung health concerns in both women and children. “Other adverse child health impacts linked to e-waste include changes in lung function, respiratory and respiratory effects, DNA damage, impaired thyroid function and increased risk of some chronic diseases later in life, such as cancer and cardiovascular disease” (Soaring). “pollutants released during e-waste recycling have been linked to adverse health consequences that include general injuries, respiratory diseases from inhalation, growth retardation, skin disease, immune weakness, neurodevelopmental effects, risks of cancer, increases in spontaneous abortions, and premature births”(Additional). “The harmful combustion byproducts released while burning e-waste can increase risk of respiratory and skin diseases, eye infections, and even cancer for people nearby”(U.S. Department).

E. Effects of E-waste Pollutants on Unborn and Newborn

The effect of the pollutants and e-waste on unborn and newborns are slightly different than those for women. Pregnant women expose their unborn children to pollutants by virtue of sharing a body and newborns through breastfeeding and environmental contamination. There is still a lack of research into pollutants’ effects on pregnant women (Kim et al. 2020). Children are more vulnerable to pollutants present at the site because of their size, underdeveloped organs, and high growth rate compared to adults on e-waste sites. Any pollutants a pregnant woman is exposed to can cause lifelong health impediments in children (Johnson 2021).

Heavy metals are commonly found on e-waste sites and can pass through the placenta to the fetus. It has been found that exposure to lead (Pb) and Cadmium (Cd) “has been associated with low birth weight and adverse neurodevelopment in children, along with other adverse pregnancy and birth outcomes” (Kim et al. 2020). A study was conducted at an e-waste site in Guiyu, China, looking at the birth outcomes associated with maternal blood concentrations of different heavy metals. This study compared the concentrations of Pb, Cr, Cd, and Mn in the blood of mothers in Guiyu and a control site, and higher concentrations of Pb, Cr, and Cd were found in the blood from mothers who were from Guiyu and the Mn concentration was higher for those from the control site. Birth length in Guiyu was also greater than the control site. Birth weight, BMI, Ponderal Index, and head circumference were less in Guiyu and all were statistically significant. “Guiyu [also] had a higher percentage of preterm birth compared to Haojiang (7.3% vs. 3.0%, respectively) which can cause complications for both mother and child” (Kim et al. 2020). The study discussed above just focused on the effects of heavy metals. Exposure to toxins from e-waste has been attributed to stillbirths, premature births, and low birth weight and length. Exposure to e-waste in children has been linked to “significantly reduced neonatal [behavioral] neurological assessment scores, increased rates of attention-deficit/hyperactivity disorder (ADHD), [behavioral] problems, changes in child temperament, sensory integration difficulties, and reduced cognitive and language scores” (Johnson 2021). Some toxins from the site are neurotoxicants like “lead, mercury, cadmium, and

brominated flame retardants," which are known to cause "cognitive deficits in children and behavioral and motor skill dysfunction across the lifespan" (Heacock et al. 2016).

Babies are primarily exposed to toxins through breast milk, to which there are few alternatives on e-waste sites in Ghana. These pollutants accrue in breast milk through a mother's exposure and are then transferred to the child. The mean concentration of PAHs in breast milk at Agbogbloshie was higher than at the control site, and "the most carcinogenic of all the PAHs, benzo[a]pyrene (BaP), was detected in 92% in the milk samples from Agbogbloshie but were below the limit of detection in all the samples from Kwabenya" (Asamoah et al. 2019). Ingesting carcinogenic PAHs can cause cancer, pulmonary diseases, and mental disabilities (Asamoah et al. 2019).

Polybrominated diphenyl ethers found in breast milk were "associated with decreases in the birth outcomes for infants, including birth weight and length, chest circumference" and "CpGs of BAI1 and CTNNA2, which are mostly responsible for neuron differentiation and development, were significantly involved in brain neuronal development in infants and had shown a close association with the elevated maternal Pb levels in the exposed group" (Li et al 2017) (Singh 2020). E-waste contamination is so pervasive, women and infants do not have to be in close proximity to sites to experience adverse effects (Kim et al. 2018).

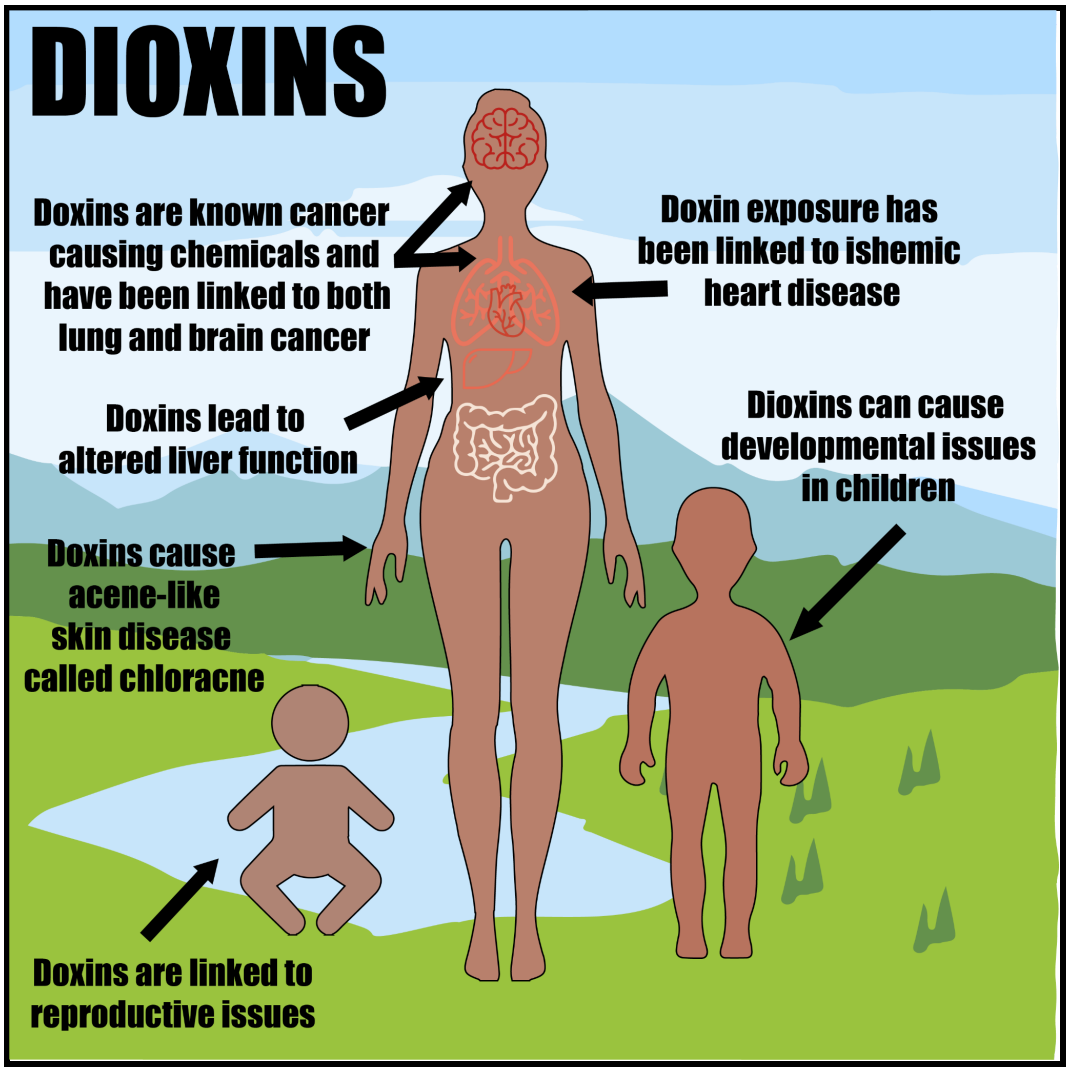

Figure 5: Effects of Dioxins on Women and Children

F. Potential Solutions to E-Waste Contamination

Solutions to e-waste contamination often include food preparation changes, limiting air pollution exposure, water filters, and plants, however, the feasibility of these solutions is largely undocumented. Most pollutants are found in food products including meat, fish, fruits, and vegetables. Dioxins in particular are found in the fat of meat and dairy products, so limiting fat ingestion can limit exposure. Alternative cooking processes might help remove different pollutants as well (Dioxins 2016). Air pollution is omnipresent on an e-waste site, so "closed windows, usually associated with the use of air conditioning in the developed world, can reduce air exchange rates by about 50%, leading to reduced infiltration of ambient air pollutants to the indoor environment"(Laumbach et al 2015). Air filtration can reduce the concentration of pollutants as well. Breathing through one's nose instead of their mouth can also reduce ingestion of airborne pollutants: "compared to the mouth, the nose is a more effective filter for preventing

particles and water-soluble [gasses] and vapors from reaching the lungs" (Laumbach et al 2015). Personal protection equipment like respirators can also limit exposure to pollutants in the air (Laumbach et al 2015). Like with air, filtration is a highly effective method of reducing exposure to toxins from water or drinking pre-packaged water from outside the site. Planting trees and other plants in the area achieves a similar effect, especially with metal-accumulating plants that undergo phytoremediation, treating contaminated soil and water (Qin et al 2021). These methods all prove helpful in theory, but may not be plausible in practice when introduced to an e-waste site. Resources are limited and schedules are strict, so many of these tactics may be forgone for pre-established concerns.

Addressing health concerns and communicating risks associated with Sub-Saharan Africa is best achieved with a smart village. Educating women on the health risks they and their children face is important to a smart village. A smart village facilitates the spread of information within a community without drastically altering the livelihoods of those involved. Health issues are communicated to the population, allowing them to decide the path they travel. Creating a smart village must be done using codesign, or it will not be smart for its inhabitants. It must involve providing information to members of the community so they can decide what must be done based on their knowledge.

G. Health Risk Perception and Communication

1. Perception

E-waste site workers and inhabitants have little concern for the risks posed by e-waste. A study done in Kenya looked at levels of perceived health risks at solid waste dumpsites, where solid waste management (SWM) is looked at. Only 42% of the participants at Mombasa and 27 % at Nairobi "perceived that there was little or no risk associated with poor SWM. Majority of the study participants believed that they were exposed to this risk through bad smell" (Amugsi et al, 2019). Both sites reported about 80% of participants claiming no adverse health effects from the waste. In Nigeria, 88% of the e-waste workers "were unable to mention at least one chemical present in e-waste, and were unaware that e-waste contains hazardous chemicals which could harm their health" (Ohajinwa et al, 2017). The population also showed overall poor knowledge of occupational health risks. This could result from the nature of the risks posed, since many people may not connect long-term health issues with e-waste. Most concerns of the e-waste workers and the people living on the site are with short-term aches and less about long-term problems (Amugsi et al, 2019). The occupational health risk awareness level is dependent on job designation, location and position in the business, especially among dismantlers" (Ohajinwa et al, 2017). Some of the workers do not even believe that they could get sick from their job, that it comes from outside factors (Ohajinwa et al, 2017).

2. Communication

Communication of health risks is important to help people understand the daily risks they face and how to avoid them. The communication of health risks must be well prepared to ensure

effectiveness (Glik, 2007). Communication has focused on health professionals instead of community members in the past, which fails to alleviate exposure (Finau, 2000). This means "a two-way interactive process [is necessary]. Merely presenting information without having regard for communicating the complexities and uncertainties of risk does not ensure effective risk communication" (Nicholson, 1999). To communicate risk effectively one should use clear and simple facts with supporting evidence and establish a bottom line immediately (Finau, 2000) (Wilhelms and Reyna, 2013). The bottom line ensures the information conveys a message that is easily understood (Wilhelms and Reyna, 2013). Risks should be framed and presented based on the community so the information feels relevant (Glik, 2007). Medical professionals are not the best for educating people because they are mistrusted by many Ghanaians. Patients' wariness even leads them to consult the internet instead of doctors for medical advice (Ancker et al, 2009). When health professionals use inaccessible language to communicate risks, they alienate people even more. Multiple forms of information should be presented and questions should be answered to encourage understanding (Larsson et al, 2006).

Visual aids show risks without relying on words or numbers, "[improving] risk communication for people with limited language skills and limited medical knowledge" (Garcia-Retamero and Cokely, 2013). Visual aids can also help patients feel more comfortable trusting physicians than verbal education, and people who benefit from the visual representations are often those more vulnerable to risk. "As long as vulnerable people have moderate levels of graph literacy, appropriate visual aids tend to dramatically improve comprehension and decision making" including bar charts, pie charts, and pictographs (Garcia-Retamero and Cokely, 2013). If the level of graph literacy is low, then these visual aids are not as helpful and other methods should be considered.

Brochures and fact sheets efficiently show risks and deliver information, however they are not particularly effective. One study showed a fact sheet showed 71 % of the participants understood a way to reduce their risk and "booklets worked better than the fact sheets, but no single format appeared to be best" (Fitzpatrick-Lewis et al, 2010). A classroom presentation proved more effective than either with 96% of participants understanding a risk reduction method because questions are able to be answered in real-time(Fitzpatrick-Lewis et al, 2010). When many people understand the risks they face, word of mouth becomes the most effective form of information transference (Larsson et al, 2006). When people hear information from their peers, they are much more likely to trust it than from health or government officials(Nicholson, 1999).

Media like newspapers or magazines and radio, TV, or social media is another effective way to convey information. Mass multimedia approaches can have a strong influence on risk perception, so they must be well researched (Fitzpatrick-Lewis et al, 2010). "Both the news media and the Internet have been criticized as often publishing inaccurate, sensationalized, or misleading stories that are not necessarily the most scientifically significant" (Glik, 2007). The public becomes suspicious of these resources when this happens, and in many instances, this is

justified when reporters report poorly prepared information (Thompson, 2019). The variety of languages in Ghana makes media campaigns difficult, but mass multimedia campaigns are the best way to spread information (Prilutski, 2010). In most of Sub-Saharan Africa, the most powerful media type is the radio, as film and other modern technologies have failed to communicate reliable information to enough people (Thompson, 2019) (Prilutski, 2010).

Health professionals in Ghana must revere the culture they communicate with. The language has to be understandable for the community (Fitzpatrick-Lewis et al, 2010). Sometimes the direct translations do not convey the correct meaning (Finau, 2000). Translations should involve members of the community to ensure understandability and give the community more ownership over the project. “The principles of “inclusion, participation and self-determination” help defeat the major problems seen with solely increasing comprehension of why a certain health behavior is wrong” (Prilutski, 2010). Integrating the community can have benefits that extend just what risks are being communicated.

H. Summary

E-waste sites have a wide variety of tasks performed on different types of electronics like computers, phones, televisions, and car parts and now provide a livelihood for lower-class families in becoming an essential part of the economy (Lawal 2019). These sites can release pollutants coming from materials like batteries and wires (Song and Li, 2014). Rain can exacerbate the pollution, causing runoff that distributes pollutants to the ground and water supply (Sovacool, 2019). The five major pathways to exposure are air, water, soil, dust, and food. The most prominent toxins are heavy metals and dioxins, which can cause cancer, neurological problems, thyroid problems, and other health conditions (Song and Li, 2014, Parvez 2021). Toxins can accrue in breast milk and expose infants, so a woman's exposure affects herself and her children (Asamoah et al 2019). Exposure to these toxins can lead to birth defects, low birth weight, stillbirths, preterm birth, and mental issues or developmental delays in children (Johnson 2021). Some solutions have been explored to help reduce the exposure, including water filters, plants that absorb contaminants in soil, and food preparation techniques like trimming the fat (Dioxins 2016, Laumbach et al 2015, Qin et al 2021). Many e-waste workers and residents do not perceive these health risks as a threat (Amugsi et al, 2019). Solutions like visual aids or lessons must be co-designed to help people without disturbing their culture or livelihood.

III. Methods and Materials

A. Research

Due to the nature of the project and how little was known about Ghana and E-waste sites, the first step of the project was to conduct extensive research into e-waste contamination in Ghana and how it affects the people. The research was broken down into three main research categories/objectives as follows, Identifying Health Risks and Contamination Sources for Women, Identifying Health Risks and Contamination Sources for Unborns/Newborns, and how

solutions will be implemented. Shared documentation locations were made for each objective and over the course of two weeks, the project members used online journal databases and search engines to find and report information onto the documents. The project members met three times a week to discuss the individual research with each other in order to set proper objectives for the next meeting, ensuring the research was always moving forward. The studies that were used came from all different sources and backgrounds including Harvard, WHO, and the Ghana Health Service. The variety of background information helped create better situational awareness of what is going on in the E-waste site regarding contamination and day-to-day life.

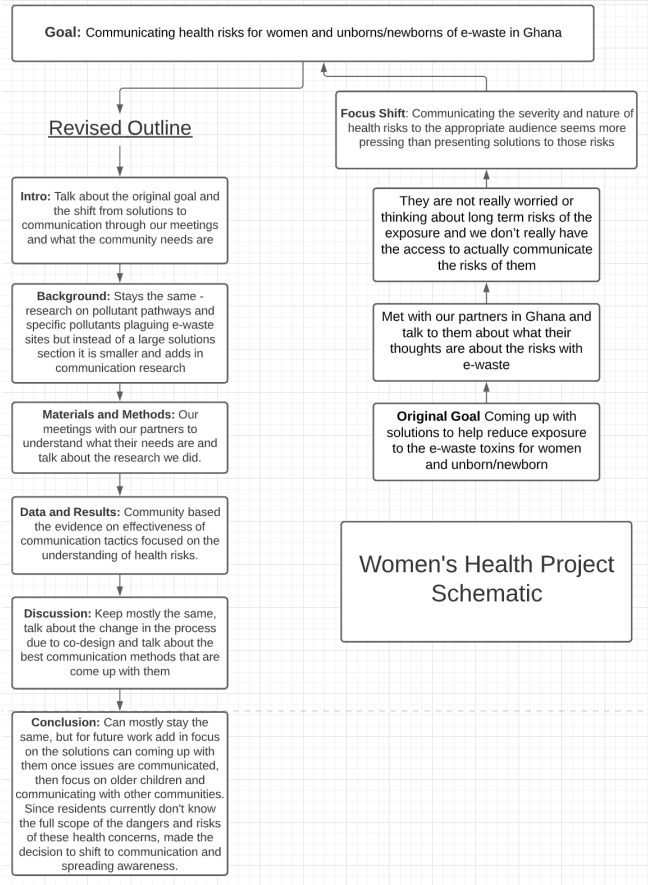

Figure 6: Schematic of the Women's Health Project

The other main area of research revolved around the basics of the E-waste site, who lives there, what they eat, where they sleep, etc. This research was conducted to provide the project members with a better understanding of what life on the e-waste site, specifically the one in Agbogbloshie. Most of this research was conducted through the use of online videos and articles provided by the residents of the e-waste sites, in addition to various drone and aerial photography provided by the advisor and google maps. This research provided the members an inside look into what occurs in the day-to-day life on the site, which was effectively reported through the text of the journals previously read. While a document was created and filled using the information found, this research was more importantly used subconsciously throughout the

meeting and design processes to make the project members more efficient at co-design with our Ghanian partners.

Once the initial research phase was complete, the documents were examined by all members to ensure a unanimous understanding of the information. The information was then organized using the outline of the case study as a reference, using its different subcategories to organize the research. Now organized, the research was directly used in the background and introduction sections of the case study, where the information could be easily found and referenced. The database of the research was constantly referenced throughout the meeting, design, and implication steps of our project when needed.

One challenge our project team had to work through was defining and creating the scope for our solution. The overall goal of working with the Ghanaian partners to reduce the exposure of E-waste contaminations for women and children was a constant, but how that would be accomplished has shifted a couple of times over the period of the project period. In order to organize our thoughts and ideas, we created several charts and documents to help visualize the next steps and the feasibility of an idea. A schematic was created (Figure 6) to help give the group members a better outlook on the outline and any changes that should be made as the project moves towards the final stages.

Once the scope of the project was altered as shown in Figure 6, a fourth and a fifth research categories came about. The first is how health risks are perceived on e-waste sites and in Sub-Saharan Africa in general and the second is how health risks or risks, in general, are communicated to the public. This research took the same process of looking at journal databases and government sites to find sources and articles relating to those topics. Then these sources were used to develop more of the background and lead to evaluating the best practices for communicating health risks on the Ghana e-waste site to women about themselves and their children. The research was evaluated by organizing and narrowing down the most effective ways to communicate to the women taking into context where they live and their culture. This was the initial evaluation that was done that was then taken to our meetings with our community partners to be discussed further.

B. Ideation sessions with community partners

In order to create the groundwork of an effective project, codesign was used throughout the research and design of our solution. Our community partners in Ghana were an essential aspect of our project as they are the ones who would work with us during the research and design phase but more importantly would integrate continuing our project into the future and making sure its impact goes beyond our short time of influence. Due to the social environment created by covid, our meetings with the project partners in Ghana had to be conducted remotely. This made implementing the co-design plan more difficult but not impossible. In order to make the best of the virtual meetings, time was spent beforehand familiarizing the team with the daily life of people on the E-waste site, so that information could be compared and questions could be

quickly generated. The initial plan was to create a list of meeting questions but after deliberation and some time and thought, the project team decided it would be more beneficial to rather come up with a list of objectives/topics to talk about to make conversations more natural and less interview-like.

The first meeting was conducted over zoom. The meeting was with a female Agbogbloshie worker who sells water sachets (Respondent 1). Julian Bennett, a Ph.D. student at Academic City University in Ghana, was able to bring a laptop to the site to serve as our ambassador for the meeting. This particular meeting served as a good initial meeting and gave the members a good reference for what to expect from future meetings. The group learned a lot from the meeting, including her daily diet, what she did for a living, and thoughts on contamination on the e-waste site. This meeting had a large influence on our project scope as it was found that people on the site not only didn't consume a large amount of meat but also had no personal experience with health concerns from E-waste contamination. This led us to believe that the workers and women on the site might not understand or know about the long-term health consequences of the e-waste. After this meeting, the goal and focus of the project shifted slightly as seen in figure 1 above.

A few weeks later another meeting was conducted with our community partners. Again Julian Bennett served as an ambassador and translator for this meeting. This meeting was with another female Agbogbloshie worker who sells bananas (Respondent 2). The group learned from this meeting about her daily life and diet, concerns she has about living on the site, and where her food comes from. It was also discussed how their routines could change and risks or anything is best communicated to help incorporate co-design of the chosen communication styles.

A connection was made with students at the University of Ghana in Accra, Ghana that was interested in working on this project. Two meetings were held with the student partners to discuss the project and their ideas. The first meeting was introductions and discussing what has been accomplished so far with the project and what their initial ideas were on it. The second meeting was after the students were able to travel to the site. This meeting gave a better insight into life on the site, perception of health risks, and how to best communicate to the community.

A meeting was also held with environmental photojournalist Mike Anane. He spent time on the site taking photos of the people living and working there. He also traveled to other smaller e-waste sites in Ghana, so he has experience with life on the sites on a smaller scale than Agbogbloshie. During conversations with Mike, he gave insight into the lives of people on the site, what they have access to, and how things are comminuted. This conversion was helping to reinforce ideas held before, while sometimes the information contradicted others.

C. Development of Graphics

The last part of the project was developing graphics based on the research that was found and the conversations that were had. There were five different graphics that were created. The first showed where and how toxins affect women, children, and infants. The second showed the

traveling of dioxins through the ecosystem and how they find their pathways to humans. The third showed different pathways, sources, and health effects for different pollutants. The fourth displays pros and cons of different communication styles done in the past. And the fifth shows the communication styles that were chosen as the best for the community and showcases how they can be used to communicate the health risks of the waste.

IV. Data and Results

The first woman we talked to, Respondent 1, says she typically gets to the site around 7:00 AM and starts setting up her station to sell the water sachets. She works all day until around 3:00 PM when she takes a break and then typically works some more till around 5:00 PM to 6:00 PM depending on how business is. She usually comes to work every day. The second woman we talked to, Respondent 2, lives very close to the site and gets up around 5:00 AM, and walks five kilometers away from the site to buy bananas to sell. Around 11:00 AM she typically starts selling, walking all around the site. She will end business between 5 pm and 8 pm depending on how the business is that day.

Our women community partners at the site said that almost all of their food comes from the site or from farms near the site. This means this is where they grow it and buy it. Breakfast for these women is typically tea and porridge. For other means, they have waakye which is rice, and beans which are typically eaten with stew and eggs. Another dish they have is T-zed which is a northern bean dish. They also eat fish from the nearby river. Their water for drinking purposes is sold in sachets called Good Pack. The water from the tap is not consumed, it is just used for cleaning. The food is typically prepared by a group of twenty women for about one thousand people on the e-waste site. This food made by the women is sold to the workers. To cook they use cobots which are communal fire/gas stoves. There are also different types of fruits and vegetables as a part of their diet, though specifics of what type of fruits and vegetables are available were not mentioned, other than bananas.

There is not much about women's daily routines/lives that can be changed. The goal on the site is to make money, other things are not of great concern to them. Respondent 2 said that if daily routines were to change it would be easier to change that of the men working on the site. The methods for cooking are fairly permanent because they do not have the resources to adapt to new methods. From the conversation with Respondent 2, she said that any type of communication is good and it probably should be in the local language of Twi because not everyone knows English.

Conversations with Mike Anane revealed young children (usually boys) as young as 7 dismantle e-waste without PPE. Men are the dominant demographic in physical e-waste processing, but women assist with burning and some disassembly. Mike also believes most people are unaware of the toxicity of e-waste and its detrimental impacts. Those aware are likely

aware because of personal experience. This reinforces the idea that communication of risk is the most important next step for avoiding the health risks of e-waste.

Overall from the conversations with our community partners, it appears there is a low-risk perception about the e-waste and the toxins that the e-waste contains or produces. They said that some health issues that they saw from the e-waste were occasional sickness, headaches, and other bodily pain from carrying water and daily strain, fever, and stomachache. Some concerns that they said they had were that they got lots of cuts, back pain, eye irritation, coughing, rain bringing waste into the area, and mosquitoes. These concerns are just overall concerns and not concerns that are specific to things relating to e-waste. With children, they just see basic cold symptoms and are not concerned much about children's health on the site. There are some people who are aware of the risks but accept them as part of daily life. Their main focus is to make money, which means that things that could prevent that from happening are ignored.

V. Discussion

A. How to Communicate

After conversations with our Agbogbloshie partners, the project's focus became communication of health risks to the people living or working on the site. From research and the conversations, best practices for communication were determined. These can be implemented in the future to be communicated to the women living and working on the site. Community integration is important for the communication of these risks. The community should be involved in creating teaching materials and communicating. The translation is another major responsibility that must fall on community members. This promotes greater ownership of ideas and motivation for others to listen while bridging the language gap. Agbogbloshie student partner meetings revealed many people at the site do not speak English and the variety of dialects makes communication difficult. Community leaders are ideal candidates for translation due to their high standing and outreach within their communities. This means providing leaders information and allowing them to translate and distribute it. Visual aids are a helpful supplement to verbal communication in distributing health information. It is important for graphics to limit words to extend accessibility. These aids are likely to be thrown out if distributed by foreigners, so community leadership is important in this as well. Technology-based communication is not the best way to communicate on Ghanaian e-waste sites. Residents often have limited education, especially regarding technology.

Figure 7 displays the pros and cons of communication methods regarding e-waste communities. It is important to consider the details of each method to determine the most effective one.

Figure 7: Pros and Cons of Different Communication Methods

Figure 8 shows a guide on how the health risk information can be communicated in an effective manner to the women on the site. This can be used as a guide for future projects on how to communicate the health risks of e-waste to women so they can then help them implement ways to reduce their exposure to e-waste.

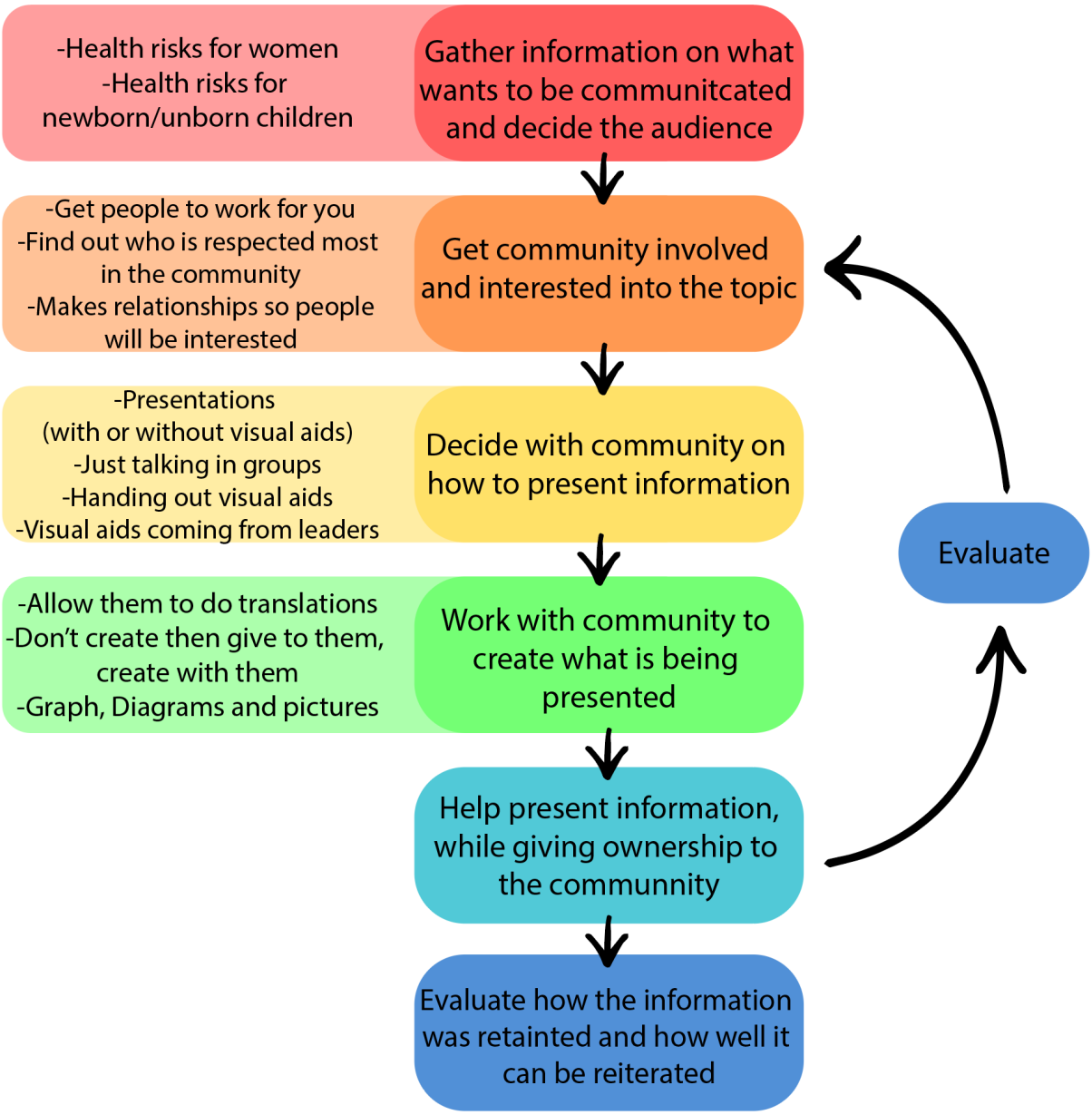

Figure 8: How to Communicate Health Risks of E-Waste in Ghana

B. Working Alongside Agbogbloshie

The opinions of Agbogbloshie residents are vital to the core of this project. In meeting with community partners, this project shifted focus from solution ideation to communication of risks. This is because many women are not aware of the health impacts posed by e-waste, and routines are difficult to change on the site. This shift addresses a more prevalent issue, allowing women in Agbogbloshie to change their own lives given the appropriate information. However, the scope of the information gathered has been limited by few meetings with women. The information gathered is useful, albeit limited in scope by logistical issues.

These conclusions were derived from discussion with these women and consideration of their values and needs.

Generative justice is crucial to our interactions with Agbogbloshie's residents. Our meetings with them were limited, so we implemented generative justice through questions about the women's daily lives, interactions with the site, and food preparation and sale. These questions incorporate generative justice by accounting for women's issues. The project is built around women because women should be able to take charge of what they have created with us. Initially, the project plan was to design and implement solutions for women to mitigate the effects of the contaminants on the e-waste site, but they are not aware of the toxic effects of living on an e-waste site. The project instead focuses on communicating the health risks of e-waste to Agbogbloshie residents. This includes providing visual aids and graphics in Twi, as well as giving this information to leaders, lending credibility to the information provided.

The intended result of the collaboration is to work with the women of Ghana to solve problems affecting women and children. Some unnecessary exposure to contaminants may be limited, and the corresponding health risks to the women and children will follow. Women on e-waste sites will therefore have a course of action to beneficially change their lives and those of all members of their community.

VI. Conclusion

E-waste sites harm the health of all who inhabit them, severely impacting women and infants who are often overlooked due to their mostly auxiliary role on the sites. Selling food and water near a site can provide as much risk as working directly with the waste, but to improve long-term health, they must understand the risks of their environment. Women often do not understand the impact e-waste and its toxins have on them. This nullified ideation of solutions because they would be useless if the issue is not well understood. Communicating the risks associated with e-waste living is the next step in ensuring residents lead healthier lives.

Given more time, further research would explore the impact of an e-waste site on older children (toddlers, school-aged children, and adolescents). Early childhood development contains the most drastic change for the human body, so e-waste contamination is especially harmful in this period. Pathways like a children's play area should be considered in future studies as well. This could be solved by moving their play area away from most e-waste. Animals and other food could be moved from the site to help mitigate dangerous toxic exposure. In Agbogbloshie, food is handled very near waste, and animals roam the site. A new site brings new opportunities to alter methods for living, like allowing animals to roam in an area cordoned away from e-waste. Once the issues are properly communicated and understood, they can be solved with the cooperation of Teacher Mante residents.

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