UNPRECEDENTED LEAD POISONING OUTBREAK IN ZAMFARA, NIGERIA: A MULTIDISCIPLINARY HUMANITARIAN RESPONSE TO AN ENVIRONMENTAL PUBLIC HEALTH DISASTER IN A RESOURCE SCARCE SETTING

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Major Professor: Douglas Lind, J.D., Ph.D.

Authorization to Submit Dissertation

This dissertation of Humphrey G. Tirima, submitted for the degree of Doctorate of Philosophy with a Major in Environmental Science and titled "Unprecedented Lead Poisoning Outbreak in Zamfara, Nigeria: A Multidisciplinary Humanitarian Response To an Environmental Public Health Disaster In a Resource Scarce Setting" has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

From 2010-2013, epidemic lead poisoning in Zamfara State, northern Nigeria was unprecedented in morbidity and mortality, as well as in the health and environmental response implemented to reduce blood lead levels and environmental exposures. More than 17,000 villagers were poisoned and 400-500 young children died from conducting artisanal gold mining. Socio-economic, logistic, and security challenges in these remote villages required a response undertaken within the context of local resources, labor practices, and cultural traditions.

This dissertation comprises three papers covering different aspects of the multidisciplinary response to the Zamfara lead poisoning outbreak. The first paper addresses remediation, which was implemented using U.S. hazardous waste removal protocols. Soil lead exposures were reduced by 97% and allowing 2,349 children to receive chelation treatment. Mean blood lead levels for children under five years of age declined from 173µg/dl to <20µg/dl over the four year remedial program.

The second paper is an investigation of dietary and para-occupational exposure pathways. Most of the dietary lead exposure was associated with contamination occurring during post-harvest processing and preparation of staple cereal grains and legumes. Average post-harvest and processed cereal grain lead levels were 0.41mg/kg and 0.85mg/kg dry weight, respectively. Contamination of cereal grains accounted for approximately 25% of total lead intake, contributing an estimated 14µg/dL to 23µg/dL increment in children's blood lead levels.

The final paper reflects on ethical dilemmas that emerged as the response unfolded. It proposes a provisional ethical framework of environmental humanitarianism which draws its features from several ethical traditions. It suggests certain characteristic that provide a basis for finding an imperative obligation to commit to a humanitarian environmental response. Such a response is called for when (1) overpowering sentiments of human sympathy or compassion suggest (2) that only humanitarian action can accord to persons suffering from an environmental disaster the respect they are due as beings with inherent worth and dignity, (3) that the action contemplated will serve overall human well-being (4) in a manner consistent with the Dunantist principles, and (5) that the action can be performed free of paternalist interference with any cultural aspects causally disconnected from the environmental disaster.

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If you want to walk fast walk alone, if you want to walk far, walk together.

– African Proverb

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Dedication

This dissertation is dedicated to my wonderful children, Gitari Ethan Gitonga Tirima and Makena Eleanor Gitonga Tirima. Thank you for your love, forbearance and for inspiring me to work on behalf of the children of Zamfara.

Table of Contents

Chapter 1

Introduction

In March 2010 evidence of epidemic lead poisoning was discovered in remote villages in Zamfara State, Nigeria. An estimated 400-500 children age five years and younger died of acute lead poisoning and many more were severely poisoned. This dissertation describes the multisectoral and multidisciplinary response to this environmental public health disaster that was developed and implemented in Zamfara over a period of 4 years. The dissertation is presented in three publishable papers covering the environmental response, an investigation of dietary and paraoccupational pathways of exposure to lead and an analysis of ethical dilemmas that emerged as the project unfolded. Following are three abstracts of the papers in order of presentation:

Abstract I: Remediation of Childhood Lead Poisoning Epidemic due to Artisanal Gold Mining in Zamfara, Nigeria

This paper will be submitted to the *Environmental Health Perspectives Journal* in December 2014.

Background: From 2010-2013, epidemic lead poisoning in Zamfara State, northern Nigeria was unprecedented in morbidity and mortality as well as in the health and environmental response implemented to reduce blood lead levels and environmental exposures. More than 17,000 villagers were poisoned and 400-500 young children died from conducting artisanal gold mining. Socio-economic, logistic, and security challenges in these remote villages required a response undertaken within the context of local resources, labor practices, and

cultural traditions. **Objectives:** To implement emergency soil remediation was necessary as a life-saving intervention. Medical treatment could not be provided to children unless residential exposures to lead were abated. **Methods:** U.S. hazardous waste removal protocols were modified to accommodate local agricultural practices. Remediation was conducted over four years in three phases, progressing from an emergency response by international personnel to comprehensive cleanup funded and accomplished by the Nigerian government. **Results:** More than 27,000 m3 of contaminated soils and mining waste were removed from 820 residential compounds and ore processing areas in eight villages, largely by hand labor, and disposed of in constructed landfills. Clean soil was used to cover the excavated areas, decreasing soil lead exposures by 97% and allowing 2,349 children to receive chelation treatment. Mean blood lead levels for children under five years of age declined from 173µg/dl to <20µg/dl over the four year remedial program. **Conclusions:** The unprecedented outbreak and subsequent response demonstrate that, given sufficient political will and modest investment, the world's most challenging environmental health crises can be addressed and resolved within the capabilities of host countries.

Abstract II: The Role of Dietary and Para-occupational Exposures among Children during the 2010-2013 Lead Poisoning Epidemic in Zamfara, Nigeria

This paper will be submitted to the *Environmental Health Perspectives Journal* in December 2014.

Background: In 2010, an estimated 400 to 500 children died of acute lead poisoning associated with artisanal gold mining in Zamfara, northern Nigeria. The principal routes of exposure were incidental ingestion and inhalation of contaminated soil and dusts, and consumption of adulterated food. Children and reproductive age women were at greatest risk due to sequestration of mothers in mud walled compounds where they engaged in both mineral and food processing. **Objectives:** A number of NGOs collaborated with the Nigerian government and international health organizations to reduce lead exposures through environmental remediation and medical treatment. **Methods:** In designing the health response, a survey of village diet and food contamination levels was conducted to determine composition and caloric and lead intake. **Results:** Most of the dietary lead exposure was associated with contamination occurring during post-harvest processing and preparation of staple cereal grains and legumes. Average post-harvest and processed cereal grain lead levels were 0.41mg/kg and 0.85mg/kg dry weight, respectively. Ingestion and absorption were likely aggravated by the dusty environment, fasting between meals, and calcium/vitamin deficiencies. **Conclusions:** Subsequent contamination of staple cereal grains accounted for approximately 25% of total lead intake, potentially contributing an estimated 14μg/dL to 23μg/dL increment in children's blood lead levels.

Abstract III: Environmental Humanitarianism: An Anthropocentric Rebound in Environmental Public Health Disaster Response

This paper is being prepared for a US Law Review Journal and will be submitted spring 2015.

In March 2010, the humanitarian medical organization Médecins Sans Frontières (MSF or Doctors Without Borders) discovered evidence of epidemic lead poisoning in remote villages in Zamfara State, Nigeria. Nigerian government authorities quickly recognized the lack of in-country capacity and expertise to deal with an environmental public health disaster of this nature and invited international agencies to assist. Further investigations confirmed that thousands of children were at risk of death or serious acute and long-term irreversible health effects due to extremely high levels of lead and also mercury. More than 10,000 people were severely poisoned, and between 400 and 500 children, most under the age of five, had already died of encephalopathy as a result of lead absorption.

As the scope of the epidemic began to unfold the international contingent recognized a clear moral imperative to help. To have turned away and done nothing for this vulnerable population would have been morally wrong. No moral or ethical theory was required to persuade the international personnel to remain in the villages and aid the victims. However, as the project and emergency response work ahead began to take shape, there evolved a clear need for an ethical framework to identify, acknowledge, and resolve the obligatory and operational dilemmas that emerged from the inevitable choices of allocating scarce resources and finite effort to a comprehensive medical and environmental response. The moral quandaries were further confounded by the volatile security situation, uncertain political context, competing health needs of the community, and unfamiliar regulatory environment and setting.

This article proposes such an ethical framework – a general ethical imperative of environmental humanitarianism. We suggest that there are certain characteristic features that guide deliberation and provide a basis for finding an imperative obligation to commit to a humanitarian environmental response. Such a response is called for when (1) overpowering sentiments of human sympathy or compassion suggest (2) that only humanitarian action can accord to persons suffering from an environmental disaster the respect they are due as beings with inherent worth and dignity, (3) that the action contemplated will serve overall human well-being (4) in a manner consistent with the Dunantist humanitarian principles, and (5) that the action can be performed free of paternalist interference with any cultural beliefs, traditions, or institutions causally disconnected from the environmental disaster.

Chapter 2

Remediation of Childhood Lead Poisoning Epidemic due to Artisanal Gold Mining in Zamfara, Nigeria

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Conflict of Interest: The authors declare they have no actual or potential competing financial interests.

Abstract

Background: From 2010-2013, epidemic lead poisoning in Zamfara State, northern Nigeria was unprecedented in morbidity and mortality as well as in the health and environmental response implemented to reduce blood lead levels and environmental exposures. More than 17,000 villagers were poisoned and 400-500 young children died from conducting artisanal gold mining. Socio-economic, logistic, and security challenges in these remote villages required a response undertaken within the context of local resources, labor practices, and cultural traditions. **Objectives:** To implement emergency soil remediation was necessary as a life-saving intervention. Medical treatment could not be provided to children unless residential exposures to lead were abated. **Methods:** U.S. hazardous waste removal protocols were modified to accommodate local agricultural practices. Remediation was conducted over four years in three phases, progressing from an emergency response by international personnel to comprehensive cleanup funded and accomplished by the Nigerian government. **Results:** More than 27,000 m^3 of contaminated soils and mining waste were removed from 820 residential compounds and ore processing areas in eight villages, largely by hand labor,

and disposed of in constructed landfills. Clean soil was used to cover the excavated areas, decreasing soil lead exposures by 97% and allowing 2,349 children to receive chelation treatment. Mean blood lead levels for children under five years of age declined from 173µg/dl to <20µg/dl over the four year remedial program. **Conclusions:** The unprecedented outbreak and subsequent response demonstrate that, given sufficient political will and modest investment, the world's most challenging environmental health crises can be addressed and resolved within the capabilities of host countries.

Introduction

In March 2010, the international humanitarian organization Médecins Sans Frontières (Doctors Without Borders, MSF) discovered an unprecedented epidemic of lead poisoning in a number of remote villages in Zamfara State, Nigeria. Subsequent investigations showed more than 17,000 people were severely poisoned and an estimated 400-500 children died as a result of lead absorption associated with artisanal gold mining/processing in residential compounds (Dooyema et al. 2011; Bartrem et al. 2013; Greig et al. 2014; Thurtle et al. 2014; WHO 2011). Several international organizations collaborated with Nigerian health authorities and local civil and traditional governments to provide emergency medical, environmental, technical, and public health response. Remediation activities, conducted in three phases from May 2010 to July 2013, were modeled on Idaho/U.S. Environmental Protection Agency (USEPA) "Superfund" protocols (NRC 2005; Sheldrake and Stifelman 2003; von Lindern et al. 2003; USEPA 2002). Post-cleanup activities included extended medical treatment in MSF-run village clinics, monitoring the sustainability of the remediation, and implementation of safer mining practices.

Remediating the villages presented numerous resource, logistic, cultural, institutional, and technical challenges. The remote area is difficult to access and has little infrastructure. Village life is ruled by overlapping civil, tribal, and Sharia governments, exhibits gender-segregated social structure, suffers numerous endemic diseases with limited healthcare, and has a workforce dependent on primitive tools and labor practices. The cleanup evolved from an emergency response initially developed and directed largely by international personnel from US firm, TerraGraphics Environmental Engineering (TG), to a multi-disciplinary program carried out by Nigerian federal, state, and local governments employing village workers. The epidemic has been characterized as unprecedented (Moszynski 2010; MSF 2010c), and the ensuing cleanup one of the largest and most comprehensive ever undertaken by an African government (World Bank 2011).

Background

When villagers first brought children with high fevers and convulsions to makeshift MSF immunization clinics, doctors did not suspect lead poisoning and initially treated for severe malaria and meningitis. When the patients failed to recover, blood samples were sent to a German laboratory that confirmed lead poisoning (MSF 2011). In May 2010, the US Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) dispatched medical and environmental investigators to work with the Zamfara State Ministry of Health (ZMOH) and the Nigerian Federal Ministry of Health (FMOH) to assess the extent of the epidemic (WHO 2011). At CDC's request, TG accompanied the mission to investigate the potential for remediation. The combined team conducted an extensive health and

environmental assessment in two villages, Dareta and Yargalma, in Anka and Bukkuyum Local Government Areas (LGAs), respectively, documenting 163 deaths and noting that up to one-third of children under age five in each village had died in the preceding few months (Dooyema et al. 2011). Surveys of six other villages suggested that 250- 350 additional children had died of lead poisoning during the height of the epidemic (MSF 2010c; Thurtle et al. 2014).

The source of the epidemic was artisanal gold mining that became prolific in 2009-10. For several months, ore processing was conducted at numerous sites within the villages. Because local religious and cultural practices include the sequestration of married women, ore crushing, washing, and gold recovery were undertaken within the residential compounds to utilize the women's labor. At some point during the rapid increase in mining activities, a dangerous ore exceeding 10% lead was introduced, severely exposing young children, pregnant women, and nursing mothers. By April 2010, with death and illness prevalent, the local Emirates ordered a temporary suspension of artisanal ore processing and later required that all operations be moved approximately one-half kilometer from the villages involved in mining. However, extremely hazardous exposures associated with residual waste and contaminated soils remained in the residential compounds and exterior processing areas.

Due to the continuing mortality, MSF/TG focused on emergency medical treatment and environmental response. MSF, ZMOH, and FMOH developed village chelation therapy clinics. However, all entities agreed that returning treated children to contaminated homes would compromise the treatment. Coupled with local resistance to relocation, this required the

villages to be remediated prior to commencing chelation. Remediation continued over three and one-half years in three phases, encompassing eight villages and 17,000 residents. More than 2,300 children under five years of age received chelation therapy (Greig et al. 2014; Thurtle et al. 2014).

Phase I remediation was an emergency response in the initial two villages (Dareta and Yargalma). MSF and ZMOH established village clinics and implemented treatment protocols. TG and ZMOE developed emergency remediation plans and protocol documents that could be implemented with resources available to the villages (von Lindern et al. 2011). Cleanup commenced in June 2010 and was suspended in mid-July due to the rainy season. The work was conducted by ZMOE with TG providing technical guidance. Funding and equipment came from Zamfara State, TG, Blacksmith Institute (BI), and MSF. Security and logistical support for the international remedial contingent was provided by the Zamfara State government and MSF. One hundred -forty-eight compounds, resident to more than 2,100 community members, were remediated, allowing MSF to provide chelation treatment to over 100 children (MSF 2010b; von Lindern et al. 2011). By September 2010, the Phase I remediation together with the suspension and relocation of artisanal mining activities had reduced the average blood lead level of children entering treatment from 173µg/dl to 86µg/dL (Figure 1).

Phase II remediation commenced in October 2010 with funding from the United Nations (UN) Central Emergency Response Fund (CERF), United Nations Children's Fund (UNICEF), Zamfara State, TG, and BI. Phase II, also conducted by ZMOE with TG oversight, addressed

five villages (Abare, Duza, Sunke, Tungar Daji, and Tungar Guru) resident to 6,385 people. An additional 1,277 children under age five years were identified as eligible for chelation treatment. Remediation activities were again suspended in March 2011, due to lack of funding and security concerns related to the Nigerian presidential election. During Phase II, further investigation by the CDC and Nigerian authorities suggested that artisanal gold mining was occurring in another 114 villages in three LGAs. Surveys of 74 of those villages found significant lead contamination in about one-half (Yi-Chun Lo et al. 2012). Another study revealed water quality problems related to the mining activities (UNEP/OCHA 2010). Additional surveys conducted by TG and ZMOE found extensive mineral processing in Bagega Village, Anka LGA, with a population exceeding 7,000, including 1,500 children under age five at severe risk. An adjacent abandoned processing site (Industrial Area) had more than 8,700 cubic meters m^3 of high concentration lead waste extending into the main water reservoir serving the region (von Lindern et al. 2011).

Phase II was followed by 18 months of advocacy encouraging the Nigerian federal government to complete the remediation. In February 2013, the federal government agreed to commence Phase III addressing Bagega. TerraGraphics International Foundation (TIFO), a non-profit humanitarian successor to TG, was retained to provide remediation oversight. Security protocols, TIFO logistics support, and all medical responses were provided by MSF. This third phase would address a larger population and remove more contaminated waste than the combined Phase I and II efforts. Phase III remediated 352 compounds and 54 common areas, rehabilitated the Industrial Area, and dredged the contaminated regional reservoir. Lead exposures were reduced for more than 7,000 residents; blood lead screening, medical

surveillance, and chelation treatment were extended to an additional 673 children. Efforts are ongoing by the Nigerian governments and the affected communities to sustain the remedy and adopt safer mining techniques.

Objectives

The overarching objective was to implement emergency soil remediation was necessary as a life-saving intervention. Medical treatment could not be provided to children unless residential exposures to lead were abated. The remediation strategy for all three phases had five primary objectives: i) develop cleanup protocols that local communities could implement, ii) decrease exposure to soil lead and other metals, iii) facilitate the MSF/ZMOH chelation program, iv) build in-country technical skills capacity for future cleanup activities, and v) develop community awareness of the dangers of artisanal mining and the measures required to protect families.

Methods

Characterization: Extensive surveys of soil, dust, and mining waste materials were conducted in each phase using a hand-held X-ray fluorescence analyzer (XRF). *In situ* surveys were conducted using the XRF. Bulk and processed (sieved) *ex situ* samples were obtained from surface soils at various depths. Testing indicated contamination within the compounds was confined largely to the top 5cm of surface soils, horizontal surfaces, soft materials (sleeping mats, cloth, etc.), and utensils used in ore processing. Large accumulations of contaminated waste, several centimeters deep, were prevalent in shady locations and near water sources throughout the villages where crushing, grinding, drying, sluicing, and storage of ores took

place. Risk assessment analyses in Phases I and II suggested that >90% of the ongoing exposure was due to incidental ingestion and inhalation of contaminated soils and dusts, and consumption of contaminated foodstuff (von Lindern et al. 2011). Contaminated wells already had been identified and provision of clean water sources had minimized the drinking water route by that time. The remediation protocol emulated successful cleanup activities undertaken at the Bunker Hill Superfund Site (BHSS) in the US. The remedial strategy was to remove contaminated soils and replace with clean soils (<25mg/kg Pb, <detection limit Hg) sufficient to reduce children's lead intake (von Lindern et al. 2011; NRC 2005; Sheldrake and Stifelman 2003; von Lindern et al. 2003).

The remediation techniques employed were designed to fit the local venues and to be implemented within the context of familiar labor practices, technology, and equipment. Deliberate efforts were made to employ local labor. Traditional farming hoes unique to the local culture were used to excavate contaminated soils from compounds. Environmental technical staff members from Zamfara state and the affected LGAs were trained to supervise remediation workers, administer payrolls, and procure materials, supplies, and equipment. In consultation with local traditional leaders they selected the labor pool. The international contingent provided quality assurance/quality control (QA/QC) services, and was responsible for database management.

Permission to access residential compounds came from the male heads-of-household with the assistance of local leaders. In conformance with Hausa cultural practices regarding gender separation, interior pre-characterization interviews with the women of each compound were

conducted by female Hausa environmental staff teams accompanied by a female international representative. The women of the households identified where mineral processing had occurred and provided family demographic information. During the actual cleanup operations Sharia traditions were amended by the local Emirate and special permission was granted to male staff and villages workers to enter the compounds.

The local environmental staff together with international technical advisors developed hand drawn maps of residential compounds and exterior areas, noting key features and showing surface XRF readings. The maps were then used to delineate where contaminated soil was to be removed, concrete placed, and materials cleaned or replaced.

Remedial Protocols: The remediation during each phase was carried out in three steps: i) excavating and evacuating contaminated media, ii) replacement with clean soils or concrete, and iii) disposal of waste. Detailed procedures were set forth in four plans developed by TG and TIFO in collaboration with ZMOE: i) Site Control Plan, ii) Excavation Plan, iii) Disposal Plan, and iv) Health and Safety Plan. However, the continually unfolding social and technical context of the cleanup required adaptability and remedial plans were re-evaluated and modified based on experience in all three phases.

Prior to beginning cleanup of a compound, residents were required to evacuate most of their belongings, including utensils, bedding, and clothing. These were thoroughly cleaned before being returned into the remediated compounds. During Phase I, sleeping mats and carpets were collected, burned at landfills, and replaced. Areas with surface soil lead

concentrations >1,000mg/kg were excavated to meet the USEPA removal threshold of <400mg/kg. Removal was accomplished by hand labor using local agricultural hoes to scrape the surface backwards (to prevent re-contamination) from the walls inward, starting at the rear of each compound and ending at the main entrance. If needed, interior compound walls were brushed to remove contaminated dust prior to excavation. Contaminated cement floors were capped with new concrete. Accumulated contaminated soils were shoveled into grain sacks, removed by wheelbarrow, and trucked to landfills. Excavated surfaces were retested to confirm that removal met or exceeded the cleanup criteria. Area surfaces with concentrations ≥400mg/kg and <1,000mg/kg were not excavated but were capped with at least 8 centimeters of clean soil.

After confirming successful removal of contaminated soils, the clean soil manager supervised the placement of at least 8cm of new soil over the excavated areas. At the discretion of the project manager, unexcavated soils with <400mg/kg lead concentration were covered with clean soil. The clean soils were obtained from landfill excavations or from separate borrow sources identified by the village elders. These soils were tested by XRF to confirm lead content <25mg/kg. Clean soil placement was confirmed on the compound and exterior maps, and entered into the project record.

When possible, exterior areas were excavated and accumulations of mine waste were removed using heavy equipment leased from local contractors or foreign mining companies operating in the region. This equipment was also used to construct the waste disposal facilities and clean soil borrow sources. In Phases I and II, most exterior removals were accomplished by hand

labor due to concern for the stability of mud walls surrounding the compounds and a lack of suitable mechanized equipment. For Phase III, the government obtained small skid steer loaders that could safely maneuver the narrow streets, greatly facilitating exterior area excavations and waste disposal.

Both heavy equipment and hand labor were used to clean several contaminated human-made village ponds. By long-standing practice, village residents constructed ponds to provide water for livestock and clay muck to make bricks for walls and housing in the late dry season. The ponds had been exploited for ore sluicing and were severely contaminated with lead and mercury. Bricks produced from the contaminated muck were found to have lead concentrations exceeding one percent. When completely dry in late February 2011 and April 2013, the ponds were excavated and closed or lined with clean soil suitable for brickmaking. Contaminated bricks were purchased and disposed of in landfills. Clean soil was delivered to the villages for brickmaking and other construction purposes. During Phase III, several thousand tons of highly contaminated industrial scale wastes were removed from the Industrial Area between Bagega village and the large regional water supply reservoir. Some of this waste material was removed to area *dabas*, or mine camps, for reprocessing to recover more gold. The reservoir, which was also highly contaminated, was drained and dredged using heavy equipment.

Contaminated soils and most mine wastes were disposed of in a series of constructed landfills outside each village. Excavated clean soil from the landfills was used to fill some ponds and repair village roads. Landfills were sited in consultation with ZMOE and village elders

familiar with seasonal groundwater levels, water holding capacity, and the structural characteristics of local soils. Landfills were typically 10m wide and 5m deep, and extended 30 to 50+m in length. Those landfills containing contaminated materials <1% lead were bottom-lined with compacted clay and closed with a 1m compacted clay cap. Phase III landfills that contained ore tailings with higher levels of lead and mercury contamination were bottom-lined with an impervious geo-membrane.

Health and safety protocols for all personnel, workers, and the public were implemented in Phase I and progressively enhanced throughout the cleanup. Health and safety training sessions were conducted in each village prior to commencing excavation and removal activities. The sessions included review of the protocol documents and the Health and Safety Plan, and emphasized hygiene, construction safety, and decontamination practices. A health and safety manager was appointed and trained for each village to ensure that best practices were implemented.

In Phases II and III of the cleanup, facilities were constructed for workers to shower, change clothes, and clean their footwear prior to leaving the cleanup sites. Ample potable water was provided on-site for hygiene and drinking. All laborers participating in excavation or evacuation of contaminated materials were given clean work clothes and dust control masks daily. Lunch was prepared and served to all project participants in specially constructed areas with water for drinking and personal hygiene. All workers were required to wash prior to being served lunch. The health and safety programs, in addition to protecting the workers and

communities affected, were aimed at modeling better practices for miners and families. Many of the cleanup laborers were miners as well.

Results

Summary results for Phases I-III remediation are shown in Tables 1-3. *In situ* XRF results showed 85% of 945 residential compounds tested exceeded the 400mg/kg soil lead remedial action level, 661 compounds were above the 1,000mg/kg excavation criteria, and 312 exceeded 5,000mg/kg. Pre-remediation soil exposures differed by phase of the cleanup. Arithmetic mean soil lead concentrations in home compounds during the 2010 Phase I emergency response in Dareta and Yargalma were 3,582mg/kg and 4,143mg/kg, respectively. During Phase II in 2011, the values ranged from 780mg/kg to 1,343mg/kg among the five villages, or about 73% lower than Phase I. Mean soil lead levels in Bagega in 2011 showed similar concentrations at 1,059mg/kg. However, by 2013, the pre-remediation mean levels in Bagega were 670mg/kg or about 37% lower than in 2011. These results suggest pre-remediation soil lead exposures decreased over time, likely due to both environmental and social factors. Environmental factors included natural dilution from soil accumulation, runoff during the highly erosive rainy seasons, and wind erosion from seasonal *harmattans* (dust storms). Socially, inadvertent remediation occurred through maintenance, repair, and construction of the mud-brick structures and regular sweeping of floors. Additionally, some families in Bagega remediated their own compounds after learning of the contamination hazards.

In total, 820 residential compounds, 181 common areas, 31 ponds, and the Bagega Industrial Area and regional reservoir were remediated. Across the three phases, 17%, 42%, and 41% of the residential cleanup were accomplished, costing an estimated $400K, $1.9M, and $3.2M USD, respectively. A total of 27,390 m^3 of soils and wastes were excavated and disposed of in fourteen constructed landfills. More than 43,000 m^3 of clean soils were imported as replacement fill and cover. Collectively, an estimated 175 metric tons of lead were removed from eight villages and the processing areas. Mean post-remediation soil lead exposures are the average value of all surface soil samples in the villages following placement of clean soils. Phase I remediation addressed 85 residential compounds and 13 common areas in Dareta, as well as 63 compounds and 11 common areas in Yargalma. Mean soil lead exposures in the two villages were reduced by 97% to less than 131mg/kg. This allowed 282 children under age five years to receive chelation treatment between June and September 2010 (CDC 2010a) (See Table 4).

Phase II remediation addressed 320 residential compounds, 181 exterior areas, and 31 processing ponds in five villages. Soil lead exposures were reduced for more than 6,000 residents from means ranging from 300mg/kg to 1,343mg/kg, to less than 150mg/kg, or 77% to 93% decreases. Five landfills, accommodating 8,981m^3 of waste and contaminated soils, were constructed and closed. Phase II also saw removal of highly contaminated materials from seven ponds in Yargalma and Dareta, and closure of landfills left open from Phase I. An additional 1,277 children became eligible for chelation treatment following Phase II. The mean blood lead level for children entering treatment after Phase II remediation was 55µg/dL compared to 86µg/dL observed following Phase I (Figure 1). During Phase II, local

government and community response activities were initiated to develop technical skills and environmental response capacity in Zamfara. Separate male and female advocacy/environmental health promotion teams were established to facilitate remediation and prevent recontamination. The Zamfara Environmental Sanitation Agency (ZESA) was created, in part to address artisanal mineral processing activities. Technology transfer, technical training, and certifications were provided to more than 200 state, LGA, and village personnel. Additionally, substantial characterization work was accomplished in February/March 2011 in anticipation of Phase III, which would address Bagega village. Nearly one-third of the residential compounds, common areas, and brick-making ponds, as well as the water reservoir and former Industrial Area adjacent to Bagega, were characterized and preliminary design and cost estimates were prepared. A 2,000 cubic meter landfill was constructed in anticipation of the Phase III remediation.

Remedial Effectiveness Evaluation: Following completion of Phases I and II in May 2011, MSF noted increasing blood lead levels in some chelation patients and suspected lead poisoning in the death of two children in the remediated villages. Follow-up environmental sampling and interviews conducted by MSF, TG, and ZMOE showed recontamination in Yargalma and Abare villages. Extensive ore processing and severe contamination levels were observed at village outskirts in re-established *dabas* and at informal processing areas under shade trees and along streams. Sampling and interviews indicated that three of 26 families surveyed had re-engaged in processing activities inside the compounds. Two of the compounds were subsequently self-remediated by the residents. Lesser recontamination was observed in other villages where workers transported contaminated dusts home on their shoes,

clothing, utensils, food products, and mining/processing equipment and materials. Children and adults who visited the *dabas* and informal processing areas to sell food also faced ongoing exposure to extremely high lead levels. Other sources of lead exposure were also identified, including cosmetic use of galena, battery recycling, bullet manufacturing, contaminated meat and agricultural products, composts, threshing areas, bricks, plaster, mortars, and various uses of spent ore waste.

Project Advocacy Campaign, November 2011-February 2013: In response to the remedial effectiveness evaluation, MSF and TIFO initiated an advocacy/outreach campaign to persuade the Nigerian federal, state, and local governments to undertake the Phase III remediation of Bagega and establish programs to sustain the remedy and promote safer mining. A three-part proposal was presented advocating that i) MSF establish a chelation clinic for the children of Bagega, predicated on ii) remediation of Bagega by the Nigerian federal government under TIFO guidance and certification, and iii) development of a safer mining program in Zamfara. The strategy was to build support for the proposal through a jointly sponsored conference/workshop convening international experts and Nigerian authorities. The conference produced a blueprint, budget, and funding commitment for the Phase III remediation scheduled to begin in September 2012 (MSF 2012).

Numerous delays in the release of cleanup funds postponed the start of Phase III remediation. Significant media attention and pressure came from several international and Nigerian NGOs (Follow the Money 2012; Human Rights Watch 2012; Murdock 2012). MSF and TIFO maintained permanent staff in Abuja from November 2012 to February 2013 to conduct

negotiations regarding project roles and responsibilities, and to secure the release of funds. In late January 2013, Nigerian President Goodluck Jonathan released $3.2M USD to FMOE to undertake the Bagega cleanup. The bulk of the work was to be accomplished by ZMOE, ZESA, LGA and local village labor. TIFO was retained to provide technical guidance and assistance, and to certify the cleanup. Upon certification, MSF would open the clinics and begin blood lead testing and treatment. In addition, the Nigerian government allocated $1.1M USD to initiate a safer mining program (Abatu 2014).

The Bagega village cleanup commenced in late February 2013 and was completed during the beginning of the rainy season in late July. A total of nearly 0.4 km^2 of surface area, comprising 352 compounds, 54 exterior areas and 1 pond were excavated and capped with clean soils. The village cleanup resulted in the disposal of ~3,700 m^3 of contaminated soil in three constructed landfills. An additional ~8,700 m^3 of waste were excavated from the abandoned Industrial Area. The reservoir was drained and dredged, yielding another ~700 m^3 of contaminated sediment. The waste materials from the reservoir and industrial area averaged 1.0% and 2.5% lead, respectively. These wastes were disposed of in a geo-membrane bottom-lined landfill. Pre-remediation soil lead concentrations averaged 670mg/kg in residential compounds and 560mg/kg in common areas. Five kilometers of village roads were graded and capped with laterite soil generated from borrow areas. Approximately 10,000 m^3 of clean soil, generated from landfill construction and borrow areas, were delivered to the village to cap excavated compounds, exterior areas, the Industrial Area, and the newly-graded village roads. In addition, a large village pond that was a drowning hazard for children was backfilled. The

remainder of the clean soil was made available to the community for use in brickmaking and other construction purposes.

The Phase III remediation impacted approximately 7,000 Bagega residents, including 1,500 children under age five. Mean soil lead exposures were reduced from 670mg/kg to 72mg/kg, or by 87%. The village was remediated in area sub-units and MSF commenced blood lead testing and treatment following completion of the first sub-units in March 2013. Phase III initial blood lead levels averaged 27µg/dL compared to 55µg/dL observed in Bagega during Phase II two years earlier (Figure 1). Chelation treatment was provided to 243 children with blood lead levels >50µg/dL (Table 4). Phase III remediation was accomplished largely by Nigerian personnel trained during Phases I and II. A total of 78 environmental professionals from FMOE, ZMOE, and LGAs directed and supervised all remediation activities including procurement and logistics. More than 300 local community members were trained to conduct the work. Local businesses provided supplies and equipment. Two on-site and four remote international staff participated in the Phase III activities, compared to 16 and 28 expatriates on-site during Phases I and II, respectively.

Discussion

The remediation efforts achieved >92% overall reductions in soil lead exposure, markedly decreasing the risk of mortality and significant adverse health effects among an estimated 17,000 individuals in eight northern Nigerian villages. Subsequently, MSF provided clinical services to several hundred families and instituted chelation treatment for approximately 2,500 children aged ≤5 years. Mean blood lead levels in village children were decreased from

173µg/dL in 2010 to <20µg/dL by 2013. New village residents and children born to mothers with low body burden henceforth would not experience high lead exposures. Similar reductions in other toxic metal concentrations were achieved simultaneously. The technical capacity of local entities to manage the remedy and undertake future cleanup activities was established. The local communities became increasingly aware of the dangers of artisanal mining and gained familiarity with the measures necessary to protect their families. Several hundred community members and local suppliers were provided jobs and acquired experience in implementing remedial protocols. The Nigerian federal government assumed the responsibility to complete the remediation and is undertaking measures to regulate artisanal mining throughout the country. At the state level, ZESA was created to undertake remediation and regulate pollution from artisanal mining. Local Anka LGA, Emirate, and Bagega district officials established committees to address artisanal mining, discourage resumption of dangerous activities, and prevent recontamination in the villages.

Despite these successes, historic exposures in the Zamfara villages were unprecedented. Nearly every village resident tested showed dangerously high blood lead concentrations. The average blood lead level for young children entering treatment during Phase I was 166µg/dl (CDC 2010b), with individual readings exceeding 700µg/dl (MSF 2010c). These exposures resulted in deaths, significant adverse health effects among survivors, and continuing body burdens of lead that may require years to equilibrate. Because the fetal skeleton develops from the mother's bone store and infants are born with blood lead levels approximating the maternal burden, the current population of mothers and young women entering marriage present an especial risk to future generations (Miranda et al. 2010; Ettinger et al. 2007; Riess

and Halm 2007). Ongoing potential health effects include adverse reproductive and child development outcomes including miscarriage, spontaneous abortion, depressed sperm counts, and decreased fertility. Irreversible neuro-psychological effects range from severe brain damage resulting in permanent dysfunction to depressed mental capacity, impairment of nerve function, behavioral and learning problems, loss of quality of life, and inability to participate in or meet village social obligations. There is also a range of possible damage to other organ systems (Caravanos et al. 2013; U.S. EPA 2013). Because treatment was unavailable for children over five years or for adults, entire generations of village residents in the contaminated areas are potentially suffering lifelong debilitating effects. This threatens these communities' collective capacity to meet minimal functions of organized social structure.

The economic contribution of small scale mining to village livelihood poses a continuing recontamination threat. Alleviating this requires all stakeholders to engage in sustainable region-wide safer mining practices. Short-term interventions implemented in 2011-13 included no longer employing women in ore processing, relocating *dabas* sufficient distances to prevent visits by children, and requiring self-remediation of re-contaminated compounds. Wet milling was introduced in 2013-14 with recommendations to wash and change clothes before going home. Longer-term efforts underway with Nigerian authorities include: i) completing remediation in other villages, ii) developing long-term monitoring, maintenance, periodic reassessment, advocacy, and public health information programs, and iii) establishing safer mining practices. The importance of implementing remedies sustainable within the capacity of the host communities is underscored by a similarly sized cleanup undertaken in 2007-10 in Kabwe, Zambia under World Bank aegis (World Bank 2011). A total of 5,986

children were recruited with 4,050 receiving treatment over three years. When the project was terminated in 2010, geometric mean blood lead levels among 1,623 children receiving treatment decreased from 93µg/dl to 66µg/dl. Follow-up blood lead surveys conducted in Kabwe in 2012 continued to show median blood lead levels of 75ug/dL, with individual levels exceeding 400ug/dL (Yabe et al. 2014). The World Bank classified the outcome as unsatisfactory, concluding the program was unable to maintain and sustain the intended interim geomean of 25ug/dL (World Bank 2011).

As opposed to contaminant removal and clean soil replacement in Zamfara, the response strategy employed in Zambia relied on Integrated Case Management (ICM) (nutritional support and behavior modification) and greening (vegetation cover) (World Bank 2011). Coincidentally, both these remedial strategies were proposed for the BHSS on which the Zamfara cleanup was modeled. The USEPA rejected the ICM/greening strategy proposed by the mining industry in favor of the more permanent removal/replacement strategy employed at both the BHSS and Zamfara sites (U.S. EPA 2002; von Lindern et al. 2011;2015). An important distinction in contrasting these remedies is that the World Bank/mining industry strategy requires continued proactive input and maintenance in communities lacking basic infrastructure and institutional resources**. C**onversely, long-term success of the Zamfara remedy depends on Nigerians refraining from potentially injurious activity that can be regulated by local traditional government, i.e. not reverting to mineral processing in their villages.

Conclusions

The Zamfara lead poisoning epidemic evolved against a backdrop of escalating environmental pollution and health damage associated with global mineral processing. High metals demand, declining ore quality, and exhaustion of accessible reserves encourages prolific exploitation of low-grade ores and legacy wastes employing dangerous techniques threatening worker and community health (Norgate and Jahanshahi 2010; Velásquez-López et al. 2011; Mudd 2010). Wealthy countries use increasing quantities of minerals, yet export both their production capacity and pollution (Slack 2012). Middle and low income countries compete to secure mineral industry investment by accepting lower environmental, community, and worker safeguards (Fasinu and Orisakwe 2013). In poor countries, high metal prices precipitate ill-advised choices to employ marginal mining, processing, recycling, and waste recovery practices. Corruption and poverty combine with a lack of standards and knowledge to produce desperate conditions among artisanal and small-scale industrial operations.

Zamfara is a severe example of this trend of the world's poorest, most remote and vulnerable populations becoming unwitting hosts to environmental and occupational disease. The blood lead levels and mortality rates were unprecedented and exacerbated by numerous risk-cofactors (Moszynski 2010). Malnutrition and childhood pestilent diseases, including measles, mumps, meningitis, polio, malaria, and cholera are endemic among these populations (Ogwumike et al. 2012; MSF 2011, 2010a). Health care services are largely non-existent. Intervention and remediation efforts were hampered by dismal infrastructure, as the villages lack electricity and running water, are one to five hours travel to the nearest paved roads, and largely inaccessible in the rainy season. Supplies and equipment had to be procured

and serviced from hundreds of kilometers away. Religious and cultural practices required strict separation of adults along gender lines, parallel male and female response teams, and in some situations, suspension of Sharia law. The cash-only economy made the transport and distribution of the large sums of money necessary for payroll, local supplies, and services a logistically complicated and dangerous undertaking. Corruption in the civil government is endemic. Crime and terrorism are constant concerns. Nevertheless, despite these complex logistical and institutional challenges, substantial remediation and subsequent medical interventions were accomplished. Over time, the capacity, authority, funding, and responsibility for the cleanup were transferred to the Nigerian federal, state, and local governments. A cadre of Zamfara state and LGA staff were trained to manage and supervise the remediation, and undertake sustainable programs to prevent future epidemics.

The Zamfara cleanup was the fifth in a series of (TG/TIFO) pilot projects to initiate environmental health responses to metals poisonings in developing countries. The cleanup model formulated to address these sites purposefully adapts US remediation techniques to local capabilities implemented through existing local institutions and employing local staff, labor, and materials. Since 2007, progressively complex remediation/health response projects have been undertaken in collaboration with international NGOs at metals poisoning sites in Far East Russia, the Dominican Republic, rural China, Senegal, and Nigeria (TIFO 2014). In each case, the early stages of the projects were accomplished with significant expatriate humanitarian direction and resources. Subsequently, responsibility was transferred to the host country's staff, management, and funding. This Nigerian project would not have been possible without: i) careful adherence to sound scientific techniques and protocols for

mitigating lead exposures through integrated remediation, treatment, and advocacy, ii) the experience gained from previous projects in adapting those techniques to local conditions in diverse cultural and geographic situations, iii) the logistics and security support provided by the experienced international organizations MSF, WHO, and CDC, and iv) the engagement and leadership provided by the Nigerian federal, state, local, and traditional governments, along with the members of the affected communities. This tragic incident and subsequent response demonstrate that, with sufficient political will and modest investment, even the world's most challenging environmental health crises can be addressed and resolved within the capabilities of the host countries.

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Figure 1. Arithmetic Mean Blood Lead Levels (µg/dL) for 0-5 Year Old Children by Cleanup Phase Initial Draw Following Remediation Prior to Chelation Treatment (MSF 2014).

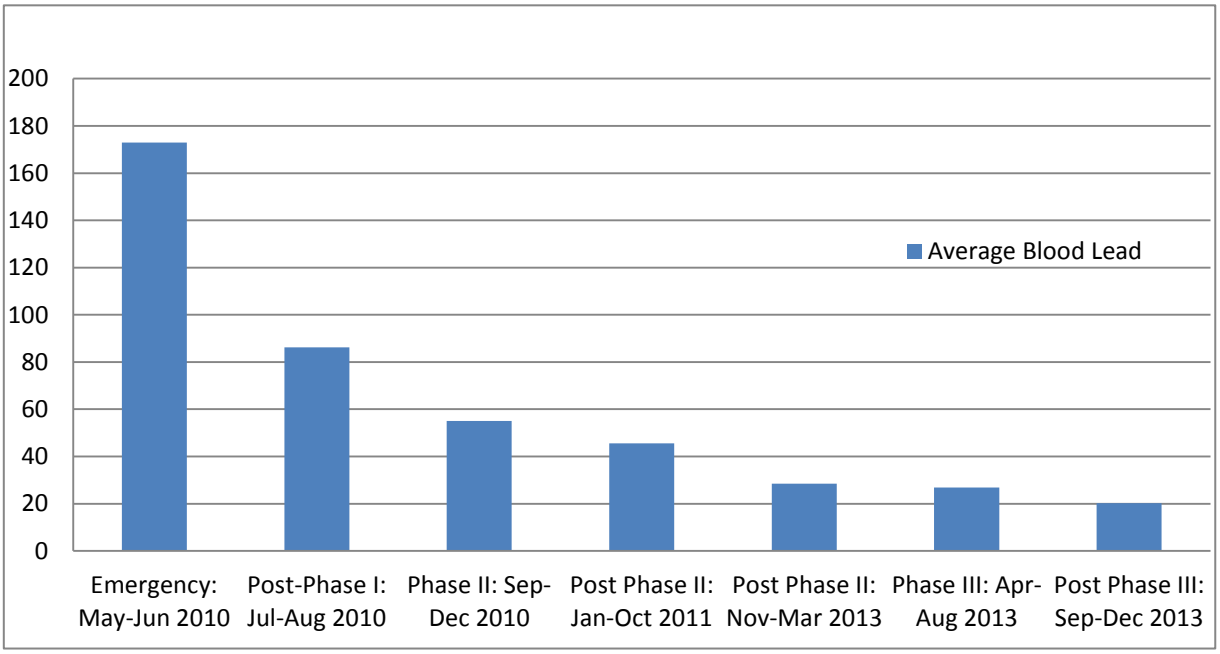

Table 1. Number of Compounds Tested by Village – All Remediation Phases.

Village	Phase	Compounds Tested	Compound Max In situ XRF Soil Lead Level (mg/kg)				Remediated		
			<400	400 - 999	1000 -4999	>5000	Compounds	Exteriors	Ponds
Dareta	I	94	9	10	22	53	85	13	4
Yargalma	I	66	3	2	15	46	63	11	3
Abare	II	96	22	17	27	30	74	20	0
Tungar Guru	II	38	7	2	15	14	31	6	1
Sunke	II	93	10	9	43	31	83	38	10
Tungar Daji	II	78	3	10	43	22	75	31	10
Duza	II	57	12	10	35	†	57	8	2
Bagega	III	423	71	87	148	117	352	54	1
All Phases		**944**	**137**	**147**	**348**	**312**	**820**	**181**	**31**

†No >5000mg/kg readings were observed in Duza

Table 2. Excavation Volume Quantities, Lead Concentrations and Disposal Quantities.

	Compounds		Exteriors		Ponds/Reservoirs		Process Waste		Total Disposal	
Phase	Volume (m^3)	Pb Level (mg/kg)	Volume (m^3)	Pb Level (mg/kg)	Volume (m^3)	Pb Level (mg/kg)	Volume (m^3)	Pb Level (mg/kg)	Volume (m^3)	Lead kg
I	2,602	3,863	417	2,649	600	11,280	300	32,000	3,919	44,039
II	5,183	1,029	2,418	2,688	1,380	13,100	N/A	N/A	8,981	47,857
III	3,343	670	1,747	560	700	8,000	8,700	10,000	10,350	109,506
Total	11,128	4,552	4,852	5,897	2,680	32,380	9,000	42,000	23,250	201,403

Table 3. Pre-and post-remediation soil lead concentrations, Phases I-III Zamfara Cleanup.

Village	Pre-remediation in situ mg/kg			Post-remediation (post excavation) in situ mg/kg		
	Average	**Min**	**Max**	**Average**	**Min**	**Max**
Dareta	3,582	40	35,380	83	25	252
Yargalma	4,143	83	23,296	179	25	400
Abare	1,343	43	18,921	90	25	400
Sunke	874	85	4,446	83	23	321
Tungar Guru	1,119	19	9,688	106	25	400
Tungar Daji	780	59	4,952	72	25	235
Duza	300	24	1779	70	25	209
Bagega	670	18	20,748	90	13	400

Table 4. Number of 0-5 Year Old Children Provided Chelation Treatment following each Phase of Remediation (Source MSF 2014).

Village	Phase I June-Sept 2010	Phase II Oct-Dec 2010	Phase II 2011	Post Phase II 2012	Phase III 2013	Total
Abare	10	208	255	86	84	633
Bagega	5	6	0	1	236	243
Dareta	101	182	86	51	53	372
Duza	0	1	53	2	0	56
Sunke	23	81	161	17	25	284
Tungar Daji	0	5	196	23	4	228
Tungar Guru	22	107	24	7	5	143
Yargalma	181	268	70	30	22	390
Total	**342**	**858**	**845**	**217**	**429**	**2349**

Chapter 3

The Role of Dietary and Para-occupational Exposures among Children during the 2010-2013 Lead Poisoning Epidemic in Zamfara, Nigeria

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Conflict of Interest: The authors declare they have no actual or potential competing financial interests.

Abstract

Background: In 2010, an estimated 400 to 500 children died of acute lead poisoning associated with artisanal gold mining in Zamfara, northern Nigeria. The principal routes of exposure were incidental ingestion and inhalation of contaminated soil and dusts, and consumption of adulterated food. Children and reproductive age women were at greatest risk due to sequestration of mothers in mud walled compounds where they engaged in both mineral and food processing. **Objectives:** A number of NGOs collaborated with the Nigerian government and international health organizations to reduce lead exposures through environmental remediation and medical treatment. **Methods:** In designing the health response, a survey of village diet and food contamination levels was conducted to determine composition and caloric and lead intake. **Results:** Most of the dietary lead exposure was associated with contamination occurring during post-harvest processing and preparation of staple cereal grains and legumes. Average post-harvest and processed cereal grain lead levels were 0.41mg/kg and 0.85mg/kg dry weight, respectively. Ingestion and absorption were likely aggravated by the dusty environment, fasting between meals, and calcium/vitamin deficiencies. **Conclusions:** Subsequent contamination of staple cereal grains accounted for approximately 25% of total lead intake, potentially contributing an estimated 14μg/dL to 23μg/dL increment in children's blood lead levels.

Introduction

In March 2010, a Médecins Sans Frontières (MSF) field surveillance team received reports from local traditional and civil government officials of high mortality rates due to suspected lead poisoning among young children in several remote Hausa villages of Zamfara State, Nigeria. Subsequent investigations by MSF, Nigerian authorities, the US Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), and TerraGraphics Environmental Engineering (TG)/TerraGraphics International Foundation (TIFO) confirmed the outbreak resulted from unregulated artisanal gold mining, involving processing of lead-rich gold-bearing ores within the villages (Dooyema et al. 2011; MSF 2011; von Lindern et al. 2011). Dust and ore tailings contaminated residential compounds in eight villages within two local government areas (LGAs), exposing thousands of residents to extreme environmental lead levels.

According to WHO, the Zamfara lead poisoning epidemic was an "unprecedented environmental emergency" (Moszynski 2010) with soil lead levels exceeding 100,000mg/kg (Lo et al. 2012; von Lindern et al. 2011; Dooyema et al. 2011; Plumlee et al. 2013) and individual venous blood lead levels greater than 400µg/dL. Within a few months of the outbreak, an estimated 400-500 children age five years and younger died of acute lead poisoning. Many more were severely poisoned with mean childhood blood lead levels exceeding 170µg/dL and were at risk of incurring irreversible neurocognitive damage (Burki 2012; Greig et al. 2014; Thurtle et al. 2014).

The combined health and environmental response has been one of the largest and most comprehensive to address a lead poisoning epidemic in a developing country. Several international organizations, Nigerian federal and Zamfara state agencies, and local civil and

traditional governments collaborated in investigating and responding to the emergency. Environmental and clinical health response activities have been ongoing since June 2010; efforts continue to introduce safer mining practices and promote awareness among the villagers to maintain the environmental remedies and prevent future tragedies (Tirima et al. 2014; von Lindern et al. 2011).

The urgency of the health crisis required a comprehensive multi-disciplinary response addressing various logistic, resource, cultural, institutional, and technical challenges. On the basis of relative risk, vulnerability, and limited resources; MSF, CDC, WHO, and state and federal Nigerian health authorities determined to establish chelation therapy for children five years of age and younger. Between June and September 2010, MSF in collaboration with the Zamfara Ministry of Health (ZMOH) and the Nigerian Federal Ministry of Health (FMOH), established chelation treatment centers in two local government hospitals near the first villages to be affected and critically ill children were transferred to these facilities. However, health authorities recognized that returning chelated children to contaminated homes would compromise their treatment. Local resistance to either relocation or foster care required that the villages be remediated to curtail ongoing lead exposure. Subsequently, MSF established outreach clinics in the remediated villages to administer outpatient treatment (Greig et al. 2014; Thurtle et al. 2014).

Cleanup began as an emergency response in June 2010 and two villages were remediated prior to the onset of the rainy season in July. Remediation recommenced in October 2010, with United Nations Children's Fund (UNICEF) support, and continued through March 2011 when funding was exhausted and security concerns around the Nigerian presidential election heightened. The first two phases of remediation reduced exposure to more than 8,000 lead

poisoned residents and allowed MSF to treat more than 1,900 children from seven villages (MSF 2012; Tirima et al. 2014; von Lindern et al. 2011).

Although the 2010-11 remediation and chelation reduced initial blood lead levels by more than 50 percent, in May 2011 MSF noted increased blood lead levels in some children under treatment. Subsequently, two deaths in remediated villages were attributed to suspected lead poisoning with blood lead levels exceeding 100μg/dL. In response to these concerns, MSF, TG, and ZMOE conducted a remedial effectiveness and exposure pathways evaluation in July 2011. Follow-up environmental sampling and interviews showed significant recontamination in two of three villages surveyed, providing a more detailed understanding of exposure pathways and co-factors influencing blood lead levels than was possible during the initial emergency response. Moreover, the investigation revealed the food supply was compromised by the complex interactions between artisanal mineral exploitation and indigenous village agricultural labor practices; including harvest, distribution, storage, preparation, and consumption. These findings were important in modifying subsequent remedial sustainability, environmental health, medical, advocacy, and institutional responses to the epidemic (Tirima et al. 2014).

This paper examines the inter-relationship of mineral processing, para-occupational risk co-factors, and adulteration of the food supply in the context of dietary/cultural habits in the villages of Zamfara. Estimates are developed regarding the ingestion of lead/dust-contaminated food and the extent to which the diet pathway contributed to the children's elevated blood lead levels.

Background

The dietary practices of the Zamfara villagers are significant both as a source of lead exposure and as risk co-factors. Intake, absorption, and subsequent toxic effects of lead and other metals are influenced by nutritional status, mineral deficiency, and periods of fasting. The influence of physiological pre-disposition and environmental, cultural, behavioral, or socio-economic risk co-factors on lead ingestion and absorption rates are relatively well understood in the US, Western Europe, and Australia (U.S. EPA 2013). However, neither the etiology nor the significance of these factors in settings such as northern Nigeria has been investigated. Understanding artisanal gold mining activities, subsequent contamination levels, and the adulteration of the food chain in Zamfara was important to both identifying and remediating all critical exposure pathways.

Mining Practices: Artisanal mining practices in remote areas world-wide are largely driven by poverty (Mallo 2012). Zamfara rural populations are extremely poor, with little formal education and limited employment alternatives. According to the International Fund for Agricultural Development (IFAD), a majority of Nigerians subsist on less than US $2 a day (IFAD 2010). The impacts of climate change on agriculture, the main economic activity in this semi-arid region, are bearing negatively on crop and animal production (Odjugo 2010; Farauta et al. 2013). Moreover, in 2011 Zamfara State had the highest unemployment in Nigeria at 42% (Leadership Editors 2012), and village rates are likely higher, as agricultural sector jobs are seasonal (Nnaji 2001). Consequently, the "gold rush" beginning in 2008-09 was a welcome relief, albeit with catastrophic environmental health consequences.

Gold deposits have been exploited in northern Nigeria since at least colonial times. An earlier gold rush took place in the 1930s, mostly by European entrepreneurs using primitive mining

methods (Ochonu 2009). As gold prices increased in the latter part of the late 2000s, these colonial legacy mines were revisited and developed into commercially viable sites, attracting hundreds of villagers and middle men to the lucrative Zamfara gold fields. Despite the large revenues generated from this gold trade, little investment in improved mining infrastructure or technology followed (WHO 2011).

Currently in Zamfara, gold-bearing ores are mined and crushed using traditional manual methods featuring primitive implements. Artisanal miners in the villages invariably prefer low cost milling of ores, using gravity concentration by sluicing as the main method for processing. Manual extraction of gold from quartz rock ore involves “pounding” (breaking and crushing) the ore to a gravel consistency using hammers and locally designed mortars and pestles. The gravel-like material is then milled using modified steel disk/plate flour mills made of a cast iron base with two enclosed vertical claw-type grinding plates. These mills are also used to grind grain. The ore is screw-fed from a conical hopper into an adjustable gap between the two plates. The hardened cast steel grinding plates, approximately 25 cm diameter, are grooved to aid the shearing (cutting/crushing) and grinding of the ore. Different groove sizes are used to vary ore texture. Generally, 50 to 200 mesh uniform powdered ores are produced and then mixed with water and sluiced to obtain a gold concentrate. This concentrate is later amalgamated with mercury. The mercury is evaporated from the amalgam by torch, leaving an unrefined sponge gold nugget. The dry processing of the ore produces enormous quantities of dust, which were deposited throughout the villages and residential living areas by wind, foot traffic, and direct disposal of tailings. The use of mercury also resulted in soil, dust, water, food, and vapor exposures.

Cultural and Dietary Considerations: Before traditional leaders and Nigerian civil authorities banned mining and milling activities in the villages due to the health emergency in May 2010, much of this gold extraction processing took place in residential compounds and village common areas. The situation was exacerbated by a religious/cultural practice called *purdah* (or *auren kulle* in Hausa), which involves the sequestration of married women in the household compounds. In order to employ women in mining operations, ores were brought into the compounds for processing resulting in widespread contamination in living areas and throughout the villages.

The Hausa household (*gida* in Hausa) is the fundamental unit of residence, production, distribution, transmission of culture, and reproduction (Adamu 2009). The *gida* is a family farming unit, often containing multiple families of several generations. The household head may have as many as four wives, and his *gida* may include his married sons and their families (Adamu 2009). The *gida* incorporates principles of Hausa social and spatial organization. Walled on the outside, with a gradation of space from *public* to *private* on the inside, the *gidas* express the gendering of space and the importance of sequestering women. The increased concern for visual privacy is exemplified in traditional Hausa architecture by high compound walls entered only by doors to the *zaure* (entrance hall) (Pellow 2002).

Most harvest food is dried, thrashed and processed by women and children within the *gida*. Grains are hand-threshed by beating on the ground, and wind winnowing. Threshed grain is stored in often specially built ovoid mud walled granaries inside or adjacent to the compounds. The compounds are constructed from local building materials such as mud (*laka*), heavy rigid timbers (*azaras*), sun dried round bricks (*tubali*), adobe bricks (*bulo*), and thatches. A small number of compounds have cement floors and corrugated iron sheet roofing. At some, adobe

bricks and plaster were made using contaminated ore tailings mixed with mud. Several households backfilled their compounds with ore tailings because it made a densely packed flooring resistant to the elements (von Lindern et al. 2011).

Almost all of the food is processed (threshed, pounded, ground, and cooked) within the compound by the women in the same confined contaminated areas where ores were processed. Mothers often pounded ore with mortar and pestles also used to prepare food. Flour mills were used for grinding both grain and ores. Box sluicing often took place inside compounds leading to the contamination of residential wells. As a result, the likelihood of contaminating food with ores and tailings was extremely high. Figure 1 illustrates food production, processing, and preparation, along with the opportunities for contamination of the food supply in these villages.

Food Production and Stages in Post-harvest System in Zamfara: Most small-holder agriculture in Zamfara is rain-fed and carried out during the single rainy season (April/May through October). Staple crops such as millet (*Pennisetum*), sorghum (*Sorghum bicolor*) and corn (*Zea mays*) are intercropped with legumes including cowpeas (*Vigna unguiculata*), groundnuts (*Arachis hypogaea*) and soybeans (*glycine max*). Rice (*Oryza sativa*) is usually grown under irrigation during the dry season. Tomatoes, hot peppers, onions, and cabbage are grown both during the rainy season and the dry season under irrigation (Bush 2013; Ene-Obong et al. 2013). Harvest from the main growing season starts in September and may continue to December depending on crop type. Dry season harvest, usually from limited irrigation, ends in March. Some families exhaust home-grown supplies by late January and purchase additional foodstuffs from wealthier neighbors or weekly markets. There is limited

dietary diversity during the food shortfall period. Families often supplement their diet with foraged foods such as baobab leaves and other wild plants (Bush 2013).

The stages in the post-harvest system for grains are shown in Figure 1. Most cereal grains and pulses are left to dry in the field as maturity coincides with the end of the rainy season. Zamfara farmers sell surplus grain through the rural assemblers, wholesalers, retailers, and consumers as well as through local processors. The points of sale are usually farm, home, village, and village and rural markets. Traditionally, un-threshed grains are stored in solid mud walled silos called *rumbus,* and can be held for up to three years before being consumed or sold.

Primary processing of grains includes cleaning, grinding, hulling, pounding, milling, grinding, tempering, soaking, parboiling, drying, and sieving. Secondary processing involves baking, frying, cooking, extruding, blending, fermenting, and roasting. Every step creates potential for contaminated soil/dust to enter the food supply. Conversely, cleaning and washing of larger seeds (maize, beans, local rice) prior to cooking can remove contaminated dust before consumption. Food is often served to children in common bowls placed on the floor. Children usually eat with their hands. This practice can readily contaminate food with soil and dust from the floor and hands.

Objectives

The objectives of this investigation were threefold: i) identify exposure pathways that remained active following the initial emergency remediation activities; ii) estimate the contribution of contaminated food to children’s blood lead levels; and iii) explore the role of cultural/dietary habits and para-occupational activities on children’s lead intake and absorption.

Materials and Methods

Remedial Effectiveness Survey: In June/July 2011, follow-up surveys were conducted at 27 compounds and 29 exterior processing areas in three villages remediated from June 2010-March 2011. Compounds were selected based on resident children's unresponsiveness to chelation treatment, i.e., children showing no significant reduction or an increase in blood lead level. Home visits were conducted by TG/TIFO environmental scientists and Nigerian counterparts. Interviews, counseling, and sampling were done to identify continuing sources of children's lead exposure. Home surveys and interviews were completed based on reconstructing a typical day, week, and month in a child's life; including compliance with treatment protocols, daily play and work activities, diet, nutrition, and hygiene practices, household modifications, and family occupational and para-occupational activities. The environmental survey included review of historic data collected from the residence and sampling of soil, dust, water, and foodstuff, as deemed necessary from the interview.

Diet Composition Questionnaire and Food Samples: Dietary intake data were obtained using a culturally sensitive food frequency questionnaire (FFQ) comprising local food items (Teufel 1997; MacIntyre and Labadarios 1999; Dehghan et al. 2005; Osowski et al. 2007; Scales 2013). The questionnaire was adapted to fit the local context by TG/TIFO field staff in collaboration with Zamfara State and local area health and environment workers and village community members. FFQs were administered face-to-face by health teams in the local language, assisted by TG/TIFO field staff. Respondents were shown common utensils and containers and asked to indicate portions by pointing out the appropriate utensil and number

of times per day, week, and month that the specific food item was consumed. Each interview took one to two hours.

Raw and processed food was obtained from local markets and weighed and measured to determine quantities captured in the FFQs. Women from the LGA were hired to demonstrate the processing (grinding, washing, cooking) of various foods in a controlled setting. Duplicate cooking was observed to confirm processing methods and portions obtained during the interviews. Replicate cooking trials using similar ingredients and recipes were conducted in the US to quantify raw, dry, and wet weight serving quantities and caloric content. Several commonly consumed plant samples were obtained from households and rural markets by TG/TIFO and CDC personnel during the cleanup activities. Other food samples were obtained from regional markets. Samples included raw food from storage bins, food processed at home or at market (e.g., by grinding with mortar/pestle or flourmill), and prepared food. The type and quantity of food samples shipped to the US for analysis were limited because of sample handling and export/import regulations (e.g., no dairy products could be analyzed). Lead concentration and *in vitro* bioaccessibility were analyzed by the USGS by inductively coupled plasma-atomic emission spectroscopy (ICP-AES) (Plumlee et al. 2013). Soil, dust and ore lead concentration and *in vitro* bioavailability were estimated by USEPA Methods 3050b and 9200B, respectively (Ian von Lindern et al. 2015; U.S. EPA 2007a, 2007b).

Potential Lead Intake and Uptake Estimates: Dietary composition and quantities were used to estimate daily caloric intakes for village children. A typical daily diet was developed based on these results, comparisons to published dietary studies in the Sahel and other sub-Saharan

populations, and MSF clinical and field observations. Dietary lead intake was estimated by combining the typical diet with the metals concentrations in the food item. Ranges of potential lead intake were developed based on variations observed in metals content and assumptions regarding contaminant removal during cleaning of stored products prior to cooking. Ranges of potential lead uptake were determined assuming 30% and 50% absolute bioavailability absorption rates (U.S. EPA 2007a). Possible contributions to blood lead levels for two-year-old children were obtained by multiplying the uptake estimate by the Harley-Kneip biokinetic coefficient for conversion of absorbed lead to blood lead concentration used in the USEPA Integrated Exposure Uptake Biokinetic model for lead (IEUBK) (U.S. EPA 2007c; Harley and Kneip 1985; Ian von Lindern et al. 2015).

Results

Recontamination Survey: Table 1 summarizes pre-remediation and post-remediation soil lead levels immediately before and after cleanup in June/July 2010 in Dareta and Yargalma, and February 2011 in Abare. Table 1 also shows soil lead results from subsequent sampling in July 2011 in all three villages. Abare and Yargalma villages showed significant recontamination in the follow-up survey, while the remedy performed well in Dareta, with modest increases in soil lead levels in a few locations. Sampling results and interviews concluded that three of 26 families surveyed had resumed significant mineral processing activities inside their compounds post-remediation. Two of these compounds were subsequently self-remediated by the residents on order of the Emirate.

Extensive recontamination also was noted at informal processing areas generally located under shade trees and alongside streams in or near the villages. The most critical exposures identified were: i) children and adults ingesting contaminants while visiting the *dabas* and informal processing areas; ii) workers transporting contaminated dusts home on shoes, clothing, utensils, and food products, and iii) storage of ores and mining/processing equipment and materials in homes. Other apparent sources of lead, unrelated to mining activities and not investigated due to limited time and resources, included cosmetic use of galena, battery recycling, bullet manufacturing, and bricks/plaster made from spent ore tailings (TerraGraphics 2011).

Food Contamination Levels: Table 2 shows dry-weight lead concentration results from ICP-AES analyses of food samples collected from Bagega village farms, households, and markets, or from the regional market in Anka. Extensive contamination of food supplies was noted in both farm and market products, with only three of 34 samples showing levels below the 0.05mg/kg detection limit. Excluding an extremely contaminated baobab leaf, samples above the detection limit ranged from 0.09 to 3.41mg/kg lead, averaging 0.66mg/kg dry weight with a geometric mean of 0.35mg/kg. Extremely high levels exceeding 1.0mg/kg lead were observed in several dried/processed market goods. Foods that had been pulverized showed significantly greater lead content, two to four times greater than raw foods obtained post-harvest or from markets.

Dietary Composition: Table 3 summarizes self-reported dietary components and caloric intake from the FFQ; caloric intake rates adjusted to published observations from similar

Sahel villages and WHO recommended intakes; and estimated lead intake, uptake, and associated blood lead increments for young children. Children's diets show a variety of foodstuffs, largely consisting of cereal grains, soybean, peanuts, sweet potato and yams, and lesser amounts of milk products. Total intake ranged from 334cal/day to 6,533cal/day among 30 families interviewed, averaging 2,468cal/day (2,013cal/day geometric mean). Peanuts and breast/cow milk accounted for 40% of total calories and cereal grains supplied 40%, with legumes, leafy greens, roots and tubers comprising the remainder. In comparison, a detailed caloric intake study conducted in nearby Zaria State estimated 810cal/day for young children, exclusive of milk products (S Oranusi et al. 2007). WHO recommends 1350 calories/day for these populations, also exclusive of milk products (WHO 1985). The Zaria study and WHO showed 340cal/day and 567cal/day, respectively, due to grains. To represent a porridge-based diet consistent with the Zaria and WHO estimates, intakes in Table 3 were adjusted to total 1,250cal/day with 450cal/day from cereal grains.

Lead intake was derived by converting caloric intake to raw weight and multiplying by lead concentration for the staple dietary components (Llobet et al. 2003; FAO/WHO 1985). The bulk of potential intake is associated with cereal grain porridge that makes up the typical childhood diet in these villages. Potential lead uptake rates from cereal grains range from 62µg/day to 106µg/day, respectively, assuming 30% and 50% absorption rates ((U.S. EPA 2002). Estimated pre-remediation blood lead increments due to food sources ranged from 14µg/dL to 23µg/dL for two-year-old children, in comparison to total mean blood lead levels of 86µg/dL to 173µg/dL observed at the peak of the epidemic (Tirima et al. 2014).

Discussion

The interrelationship between mineral and food processing in the Zamfara lead poisoning epidemic is complex and affects sources, intake rates, absorption, and subsequent health effects. Because of gender sequestration practices, both minerals and food were processed and prepared by women and children in the same residential locations, often using the same equipment. Dusts generated during the mining activities severely contaminated compound interiors, where reproductive age women and young children spend their entire days. Para-occupational activities and adulteration of the food supply in these residential settings were also major contributors to lead absorption during the epidemic, and likely continued until stored grain supplies were depleted.

Most food contamination occurred post-harvest during threshing, processing, and preparation within the compounds. Plant uptake of metals was likely minimal. Field observations showed that relatively small portions of village cropland were contaminated and that little ore processing took place near the fields (Abdu and Yusuf 2013; Plumlee et al. 2013). Several studies suggest that uptake of inorganic lead by commonly grown garden plants is relatively low, and that human ingestion of adhered contaminated dust is of greater importance than uptake of trace minerals by plants (Roy and McDonald 2013; Lee et al. 2013; Intawongse and Dean 2006). Additionally, USGS chemical and electron microscopy analyses of high lead content in both raw and processed food samples from the Zamfara villages revealed the same metallic species composition as the ores, village soils, and interior home sweep samples (Plumlee et al. 2013). These compounds, rich in lead carbonates and oxides, showed absolute bioavailability greater than 30% and can easily dissolve in gastric juices (Cornelis 2005;

Mushak 2011; Plumlee et al. 2013). The same analyses suggest that processed foods, especially those pulverized in the residential compound kitchens, showed greater lead levels than raw or market foods.

Banning ore processing in the villages and establishing *dabas* remote from the settlements excluded reproductive age females from employment, greatly reducing their direct exposures. However, para-occupational lead exposure due to other family members working in the *dabas* remains a risk factor (Chan et al. 2000; Dolcourt et al. 1978; Knishkowy and Baker 1986). Lead is brought home on workers' clothing and contaminated working materials such as head pans, shovels, and sacks. Processed ores are often stored in the compounds for security reasons. Older children are sent to the *dabas* to sell food items such as groundnut cakes, deep fried tofu, and gruel; where they are exposed to contaminated dusts and can carry lead back to the home. The food is often displayed in open containers and can easily be contaminated by lead dust from ore processing or dirty hands. Unpurchased food is returned home for family consumption at the end of the day. Polluted water is another source of contamination, as sluicing continues in some streams that feed open wells where food is often washed. Some open wells tested early during the epidemic were found to exceed WHO and Nigerian lead standards (10μg/l), in at least one case by more than tenfold. These wells may have contributed to dietary lead prior to being rehabilitated in 2011 (UNEP/OCHA 2010). However, most villagers used village boreholes for domestic water which showed lead levels below the health standard.

Self-reported caloric intakes calculated from the FFQ survey showed large variation, ranging from moderate malnutrition to suspiciously high levels among some families, possibly reflecting relative affluence, individual preferences, or over-reporting. MSF clinics noted that some children entering treatment showed symptoms of malnutrition (Greig et al. 2014; Ebiloma 2013; Thurtle et al. 2014). The overall average caloric intake self-reported in the FFQ is about twice the WHO recommendation and well above similar families in the Sahel (FAO/WHO/UNU 2004; Ross 1997; WHO 1985). As a result, the intake estimates are likely biased high as frequently occurs in self-reporting (Wojtusiak et al. 2011; Chemaly et al. 2004; Shahar et al. 2003; MacIntyre et al. 2001). Additionally, observations made by the authors while living in the villages suggest that the consumption of peanuts and milk products by children was likely overestimated. The availability of dairy products is seasonal, depending on nomadic Fulani herdsmen who follow the rainfall patterns across the Sahel and spend only a few months in Zamfara. Peanut consumption is also seasonal and often reserved for sale of groundnut sweet cakes eaten by adults. As a result, the lower caloric intake estimates developed in Table 3 are likely more representative of children's typically cereal porridge-based diet (Onofiok and Nnanyelugo 1998; FAO 1999).

Most of the suspected dietary lead intake was attributable to staple gruels made from corn, sorghum, millet, and local rice pulverized in home compounds. These sources contributed as much as 100μg/day of lead to young children as mineralized dust adhering to raw food, or introduced post-harvest during processing. In comparison, the WHO drinking water guidance for lead of 10μg/l is based on 3.5μg/day/kg body weight for a 5kg infant or about 18μg/day

(WHO 2008). In 2010, WHO acknowledged these criteria were insufficient to protect against adverse neurological effects and withdrew the recommendation (WHO 2010).

In vitro bioaccessability tests on 12 ore, soil, and dust samples from the villages ranged from 6% to 66%, averaging 54% (Plumlee et al. 2013). Eleven soil and ore samples analyzed by EPA Method 9200B showed *in vitro* absolute bioavailability ranging from 17% to 41%, averaging 33%. The absorption rate for food-born lead in the villages likely varies between 30% and 50%, the latter recommended for dietary lead in the IEUBK model (U.S. EPA 2002). Lower rates may be considered, as the contaminant is mainly soil-borne particulate adhered to food. However, higher absorption rates may apply as the village diet is calcium, vitamin, and protein deficient; fasting between meals is common; and caloric intakes are lower seasonally when food supplies decline (Liu et al. 2011; Gallicchio et al. 2002; James et al. 1985; Rabinowitz et al. 1980). As a result, potential mean blood lead increments from adulterated food were calculated at 30% and 50% bioavailability, respectively, and ranged from 14μg/dL to 23μg/dL. Food exposures were evaluated during the second phase of remediation in 2011, when pre-remedial blood lead levels averaged 55μg/dL to 86μg/dL. At that time, adulterated food potentially contributed 16% to 42% of absorbed blood lead, or perhaps 25% overall, with the largest component due to incidental ingestion of contaminated soils and dusts (Tirima et al. 2014; TerraGraphics 2011; von Lindern et al. 2011).

Because the principal source of lead in food was soil contamination in the residential compounds and common processing areas, the soil remediation program ultimately addressed this exposure route (von Lindern et al. 2011; Tirima et al. 2014). However, the marketing of both raw and processed foods, especially at *dabas*, prolonged transport of lead contamination

to and from the villages. These exposures continued until the contaminated foods stores were depleted. Other villages in Zamfara could have experienced similar lead exposures and their residents may have marketed adulterated food in the region. The extent of these practices is unknown. The feasibility of abating the food source directly is doubtful in these largely subsistence farm communities, as market forces undermine attempts to ban contaminated foods outright. Worry over food safety can lead to the routing of contaminated foods to the poorest, often unaware, villagers. Elimination of all sources of food contamination and sustainability of the Zamfara remediation depends on civil and traditional governments working with local leaders to establish and maintain safer mining practices and to discourage children and reproductive age women from participating in mineral processing.

Conclusions

Rudimentary artisanal gold extraction by processing ores with high lead carbonate and oxide content within these remote Zamfara village residential areas resulted in severe soil and dust lead contamination. The cultural practice of gender sequestration, in compounds where both mineral and food processing was undertaken, horrifically exacerbated exposures for women and young children, resulting in mean blood lead levels exceeding 170μg/dL, severe morbidity, and 400-500 deaths.

Incidental hand-to-mouth ingestion of lead-contaminated soil and dust by children and dietary exposures due to food adulteration during processing and preparation were the primary exposure pathways. The emergency removal of contaminated soil largely eliminated the soil sources and allowed medical treatment to commence, substantially reducing children’s blood

lead levels. However, follow-up remedial effectiveness surveys showed recontamination by renewed mining, para-occupational practices, and continuing dietary exposures.

The food pathway was poorly understood at the beginning of the epidemic. Specific studies were undertaken to characterize this exposure route and associated socio-economic, cultural, and demographic risk co-factors. Dietary exposure was found to be a significant source, contributing an estimated 25% to absorbed blood lead in the period following relocation of village processing, but prior to remediation. Most food contamination was due to ore particles adhered to staple cereal grains introduced during home processing in contaminated areas or using contaminated equipment and utensils.

These pathways were ultimately addressed by banning mining in the villages, establishing remotely located processing areas (*dabas*) that precluded participation by adult females and young children; eliminating the residual sources through soil remediation; and introducing and enforcing safer mining practices to minimize occupational and para-occupational exposures. The long-term sustainability of these efforts depends on local civil, traditional, and religious governments' and villagers' continued adherence to these protective measures.

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Table 1. Summary Mean Soil Lead Levels in Compounds Selected for the Followup Remedial Effectiveness Survey (6-9 months after Cleanup) (mg/kg Pb).

Village	Sampling Period		Compounds tested (N)	Mean Soil Lead Concentration (mg/kg) Minimum	Maximum	Arithmetic Mean	Geometric Mean
Abare	Pre-remediation	Oct-10	9	191	6953	2279	1284
	Post-remediation	Dec-10	74	25	400	90	n/a
	Effectiveness survey	Jun-11	9	79	2108	853	665
Dareta	Pre-remediation	Jun-10	9	258	21333	7351	4395
	Post-remediation	Jul-10	85	25	252	83	n/a
	Effectiveness survey	Jun-11	9	227	630	460	439
Yargalma	Pre-remediation	Jun-10	9	657	16295	5076	3082
	Post-remediation	Jul-10	63	25	400	179	n/a
	Effectiveness survey	Jun-11	9	223	5341	1398	929

Table 2. Lead Contamination Levels in Local Foodstuff (ICP-AES Results – dry weight).

Food Type	Location Obtained	Notes	Pb (mg/kg)
Cereal Grains: Processed (Ready to cook or eat)			
Sorghum	Bagega village	Dried, pounded, milled into flour, ready to cook	2.06
Millet	Bagega village	Ground, ready to cook	0.66
Bread (white)	Bagega bakery	Crushed bread, dried 3 days and pulverized	0.31
Bread (white)	Bagega bakery	Crushed bread, dried 3 days and pulverized	0.92
Wheat flour	Gusau market	Sifted wheat flour	0.32
		Arithmetic Mean for Food Type	*0.85*
		Geometric Mean for Food Type	*0.66*
Cereal Grains: Harvested, thrashed, stored			
Sorghum	Bagega village	Whole grain	0.93
Sorghum	Bagega farm	Whole grain	0.41
Sorghum	Anka market	Whole grain	< 0.05
Millet	Bagega farm	Whole grain	< 0.05
Millet	Anka market	Whole grain	0.53
Corn	Bagega farm	Whole grain, yellow dried hard kernels	0.27
Corn	Anka market	Whole grain, yellow dried hard kernels	0.12
Local rice	Bagega market	Whole grain	0.73
Local rice	Bagega farm	Hulled	< 0.05
Local rice	Bagega farm	Whole grain rice with hulls	0.20
Local rice	Anka market	Whole grain rice with hulls	0.44
White rice	Anka market	Whole grain	0.09
		Arithmetic Mean for Food Type	*0.41*
		Geometric Mean for Food Type	*0.32*
Legume Grains (Pulses): Processed (Ready to cook or eat)			
Soybean (fermented)	Bagega market	Boiled, pounded into disks, dried, ready to eat	3.41
Soybean (fermented)	Anka market	Boiled, pounded into disks, dried, ready to eat	0.443
Peanut	Bagega village	Pounded/crushed read to eat	0.915
Peanut	Anka market	Paste ready to eat	0.104
		Arithmetic Mean for Food Type	*1.218*
		Geometric Mean for Food Type	*0.616*

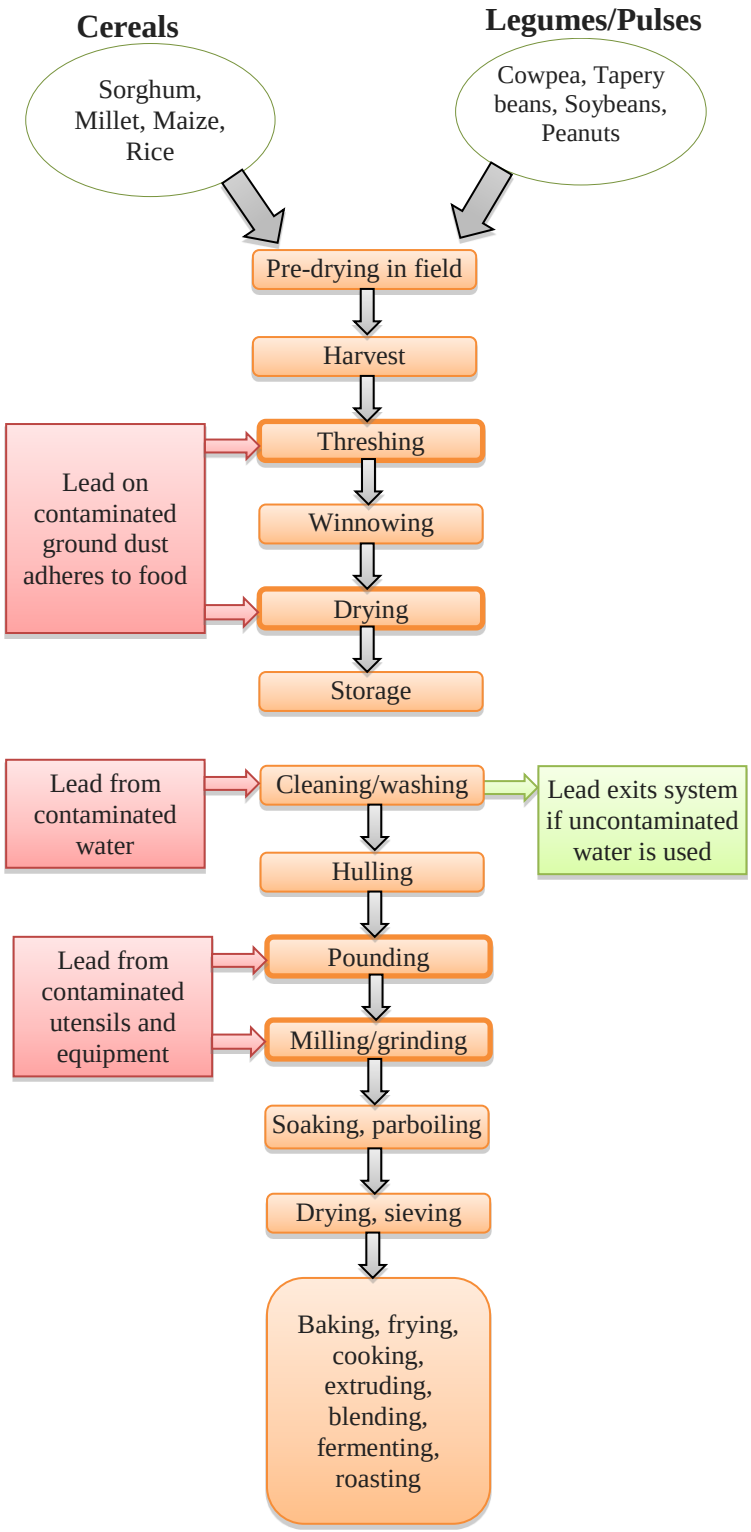
Table 2. *Continued from previous page*

Food Type	Location Obtained	Notes	Pb (mg/kg)
Legume Grains (Pulses): Harvested, thrashed, stored			
Cowpea	Bagega village	Whole	0.244
Cowpea	Bagega farm	Whole	0.39
Cowpea	Anka market	Whole	0.356
Tapery bean	Anka market	Whole	0.0816
		Arithmetic Mean for Food Type	*0.268*
		Geometric Mean for Food Type	*0.229*
Sun Dried Vegetables, Herbs, Fruits and Spices			
Sun dried baobab leaves	Bagega market	Dried, ready to cook	146
Sun dried tomatoes	Bagega market	Dried, ready to cook	0.302
Ginger root	Anka market	Dried ginger root, ready to cook	1.86
Sun dried chilies	Anka market	Dried and pulverized, ready to cook	0.617
Sun dried okra	Anka market	Dried okra, ready to cook	0.177
Tamarind	Anka market	Pods, ready to cook/eat	0.477
		Arithmetic Mean for Food Type	*24.906*
		Geometric Mean for Food Type	*1.274*
Traditional Medicines and Herbs			
Medicine	Bagega market	Local medicine	0.69
Medicine	Bagega market	Local medicine	0.786
Medicine	Bagega market	Local medicine	2.72
		Arithmetic Mean for Food Type	*1.399*
		Geometric Mean for Food Type	*1.138*

Table 3. Estimated Food, Caloric and Lead Intake Rates, Absorbed Lead and Predicted Blood Lead Increments for Children – Zamfara Lead Poisoning Epidemic – 2011-2012.

Food Item	Reported Raw Weight Intake		Reported Caloric Intake		WHO** Adjusted Caloric Intake		WHO** Adjusted Intake (raw wt)		Estimated Pb Intake		Estimated Absorbed Pb (50% Bioav.)		Estimated Blood Pb Increment (2 yr old)	
Cereal Grains														
Corn	222	g/day	207	cal/day	104	cal/day	111	g/day	22	µg/day	11	µg/day	4.4	µg/dL
Sorghum	126	g/day	421	cal/day	210	cal/day	63	g/day	54	µg/day	27	µg/day	10.9	µg/dL
Millet	9	g/day	11	cal/day	5	cal/day	4	g/day	2	µg/day	1	µg/day	0.4	µg/dL
Local rice	130	g/day	154	cal/day	77	cal/day	65	g/day	24	µg/day	12	µg/day	4.9	µg/dL
White rice	95	g/day	113	cal/day	56	cal/day	47	g/day	4	µg/day	2	µg/day	0.9	µg/dL
subtotal	*581*	*g/day*	*906*	*cal/day*	*453*	*cal/day*	*291*	*g/day*	*106*	*µg/day*	*53*	*µg/day*	*21.4*	*µg/dL*
Legume Grains (Pulses)														
Cowpea	36	g/day	32	cal/day	16	cal/day	18	g/day	6	µg/day	3	µg/day	1.2	µg/dL
Tapery bean	26	g/day	23	cal/day	12	cal/day	13	g/day	1	µg/day	1	µg/day	0.2	µg/dL
Soybean	139	g/day	139	cal/day	69	cal/day	69	g/day		µg/day		µg/day		µg/dL
Peanut	100	g/day	575	cal/day	287	cal/day	50	g/day		µg/day		µg/day		µg/dL
subtotal	*300*	*g/day*	*769*	*cal/day*	*385*	*cal/day*	*150*	*g/day*	*7*	*µg/day*	*3*	*µg/day*	*1.4*	*µg/dL*
Roots/Tubers														
Sweet potato	146	g/day	146	cal/day	73	cal/day	73	g/day						
Yam	100	g/day	100	cal/day	50	cal/day	50	g/day						
Potato	32	g/day	25	cal/day	13	cal/day	16	g/day						
subtotal	*278*	*g/day*	*271*	*cal/day*	*135*	*cal/day*	*139*	*g/day*						
Dairy														
Breast milk	383	ml/day	294	cal/day	147	cal/day	191	ml/day						
Cow milk	345	ml/day	216	cal/day	108	cal/day	173	ml/day						
Goat milk	52	ml/day	36	cal/day	18	cal/day	26	ml/day						
subtotal	*780*	*ml/day*	*546*	*cal/day*	*273*	*cal/day*	*390*	*ml/day*						
Total	**1939**	**g/day**	**2492**	**cal/day**	**1246**	**cal/day**	**970**	**g/day**	**113**	**µg/day**	**57**	**µg/day**	**22.9**	**µg/dL**

Figure 1: Lead dust contamination of food and the post-harvest system for grains in Zamfara.



Chapter 4

ENVIRONMENTAL HUMANITARIANISM: AN ANTHROPOCENTRIC REBOUND IN ENVIRONMENTAL PUBLIC HEALTH DISASTER RESPONSE

"There once … [were villages] … where all life seemed to live in harmony with its surroundings…. Then a strange blight crept over the area and everything began to change…. Everywhere was a shadow of death. The farmers spoke of much illness among their families. In the town, the doctors had become more puzzled by new kinds of sicknesses appearing among patients. There had been several sudden, unexplained deaths … among children…. No witchcraft, no enemy action had silenced the rebirth of new life in this stricken world. The people had done it themselves." – Rachel Carson[1]

INTRODUCTION

In March 2010, the humanitarian medical organization Médecins Sans Frontières (MSF or Doctors Without Borders) discovered evidence of epidemic lead poisoning in remote villages in Zamfara State, Nigeria. An MSF disease surveillance team received reports from local leaders and health officials of anomalistic increases in childhood illness and death in two villages in the Bukkuyum and Anka Local Government Areas (LGAs). Analysis of the affected children's case histories revealed that the symptoms presented, progression of their illnesses, and their response to treatment were not consistent with any likely local causes of

[1] RACHEL CARSON, SILENT SPRING (Houghton Mifflin; Riverside Press 1962).

illness.[2] The incipience of these cases predated the usual onset of seasonally endemic diseases, and treatment with malaria and meningitis therapies had no impact.[3] With the permission of the Nigerian authorities, MSF investigators sent blood samples from some of the ailing children to a German laboratory for diagnostic testing.[4] Heavy metal poisoning was identified as the culprit, as all samples showed blood lead levels well above the 70 µg/dL (micrograms of lead per deciliter) threshold for urgent treatment.[5] These results precipitated the immediate need to confirm the diagnosis in Zamfara and characterize the disaster to support development of appropriate interventions.

Nigerian government authorities quickly recognized the lack of in-country capacity and expertise to deal with an environmental public health disaster of this nature. In May 2010, the Nigerian Federal Ministry of Health (FMOH) requested assistance from the US Centers of Disease Control and Prevention (CDC) to conduct an assessment in the Bukkuyum and Anka villages to ascertain the nature and extent of the suspected epidemic. The American firm TerraGraphics Environmental Engineering (TerraGraphics) joined the CDC team and the NGO Blacksmith Institute provided equipment for the environmental assessment portion of the CDC survey. The results were shocking. Hundreds of children had died due to lead

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[2] Jane Greig et al., *Association of Blood Lead Level with Neurological Features in 972 Children Affected by an Acute Severe Lead Poisoning Outbreak in Zamfara State, Northern Nigeria,* 9 PLOS ONE e93716 (2014).
[3] MSF, *Field Journal: Nigeria* (Jan. 3, 2011), *available at* https://www.doctorswithoutborders.org/publications/alert/article.cfm?id=5013&cat=alert-article.
[4] UNEP/OCHA, *Lead Pollution and Poisoning Crisis Environmental Emergency Response Mission Zamfara State, Nigeria September/October 2010* (Nov. 2010), *available at* https://docs.unocha.org/sites/dms/Documents/Lead Pollution and Poisoning Crisis Environmental Emergency Response Mission Zamfara State Nigeria 2010.pdf; Carrie A. Dooyema et al., *Outbreak of Fatal Childhood Lead Poisoning Related to Artisanal Gold Mining in Northwestern Nigeria, 2010,* 120 ENVIRONMENTAL HEALTH PERSPECTIVES 601 (2011).
[5] Dooyema et al., *supra* note 4.

poisoning associated with artisanal mining and processing of lead-rich gold ores in their family residential compounds. Hundreds more were severely poisoned with mean blood lead levels of 119 micrograms per deciliter of blood (μg/dL).[6] According to the CDC, blood lead levels as low as 10μg/dL are associated with impaired physical and neurological development in young children.[7] Soil lead concentrations greater than 100,000 milligrams per kilogram (mg/kg) were found in and around residential areas in the villages. Sweepings of dust from the compound floors often exceeded 2% lead (20,000 mg/kg).[8] The US EPA defines a soil lead hazard as bare soil containing lead greater than 400 mg/kg for residential soils.[9] The emergency investigation in Zamfara concluded that the children in the villages were poisoned mainly through incidental ingestion of lead contaminated dusts.

Subsequent investigations by the CDC, the World Health Organization (WHO), and the ZMOH confirmed that thousands of children were at risk of death or serious acute and long-term irreversible health effects due to extremely high levels of lead and also mercury. More than 10,000 people were severely poisoned, and between 400 and 500 children, most under the age of five, had already died of encephalopathy as a result of lead absorption.[10]

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[6] *WHO, Nigeria: mass lead poisoning from mining activities, Zamfara State, available at* http://www.who.int/csr/don/2010_07_07/en/index.html.
[7] CDC, *Interpreting and Managing Blood Lead Levels <10 μg/dL in Children and Reducing Childhood Exposures to Lead: Recommendations of CDC's Advisory Committee on Childhood Lead Poisoning Prevention*, 56 MMWR 1, 1 (2007).
[8] Ian von Lindern et al., Zamfara, *Nigeria Lead Poisoning Epidemic Emergency Environmental Response, May 2010 - March 2011*, Final Report to the United Nations Children's Fund (UNICEF) (2011), *available at* http://terragraphicsinternational.org/wp-content/uploads/2013/11/Zamfara_Emergency_Response_UNICEF_Final_Report.pdf.
[9] U.S. EPA, *Regional Screening Table - User's Guide: Mid-Atlantic Risk Assessment, available at* http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm.
[10] Greig et al., *supra* note 2; Geoffrey S. Plumlee et al., *Linking Geological and Health Sciences to Assess Childhood Lead Poisoning from Artisanal Gold Mining in Nigeria*, 121 ENVIRONMENTAL HEALTH PERSPECTIVES 744 (2013); von Lindern et al., *supra* note 8.

As the scope of the epidemic began to unfold, the MSF, WHO, CDC, and TerraGraphics personnel recognized a clear moral imperative to help. To have turned away and done nothing for this vulnerable population would have been morally wrong. No moral or ethical theory was required to persuade TerraGraphics and MSF personnel to remain in the villages and aid the victims. However, as the project and work ahead began to take shape, there evolved a clear need for an ethical framework to identify, acknowledge, and resolve the obligatory and operational dilemmas that emerged from the inevitable choices of allocating scarce resources and finite effort to a comprehensive medical and environmental response. The moral quandaries were further confounded by the volatile security situation, uncertain political context, competing health needs of the community, and unfamiliar regulatory environment and setting.

This paper proposes such an ethical framework – a general ethical imperative of environmental humanitarianism. We do not derive this principle from a single moral philosophy, but fashion it from a range of normative considerations and precepts. Much of the case material used to develop the ethic comes from the work accomplished by the Nigerian governments, MSF, and TerraGraphics in the remote villages of Zamfara State, Nigeria, in response to the lead poisoning crises.

ZAMFARA LEAD POISONING EMERGENCY RESPONSE

The British Medical Journal has termed the Zamfara lead poisoning epidemic as "unprecedented."[11] The high mortality rates, severity of poisoning, large number of children exhibiting symptoms of lead poisoning, and levels of environmental contamination, coupled

[11] P. Moszynski, *Lead Poisoning in Nigeria Causes "Unprecedented" Emergency*, 341 BMJ c4031 (2010).

with high levels of poverty, illiteracy, poor infrastructure and a lack of basic services precipitated a calamitous situation in the villages of Zamfara.

Clearly, the diagnoses, both environmental and clinical, were overwhelming and beyond the day-to-day capacity of the statutory authorities. The Zamfara state government requested MSF and TerraGraphics, respectively, to provide medical treatment and develop emergency environmental remediation plans to be implemented in the two villages where the lead poisoning was first discovered.[12] As the environmental cleanup commenced, MSF and the ZMOH developed clinical facilities and implemented medical treatment protocols using chelating agents targeting children five years and younger. All entities involved in the emergency response agreed that returning patients receiving chelation therapy to contaminated homes and villages would compromise the treatment and put the children at extreme health risk. As a result, it was requisite to complete remediation prior to treating the children. The remediation effort was accomplished over three and one-half years in three phases.[13]

Phase I, which started in June 2010, was an emergency response. It addressed two villages, Dareta and Yargalma, in the Anka and Bukkuyum LGAs, respectively. The cleanup protocols and methodologies used to remove the contaminated soils and mining wastes in Zamfara were based on years of TerraGraphics' experience at the Bunker Hill Superfund Site in Idaho, USA, adapted to suit local conditions, tools, and available equipment and materials.[14] TerraGraphics provided technical guidance for the cleanup activities which were funded mainly by the Zamfara State government. Remediation of the two villages was

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[12] Simba Tirima et al., Remediation of Childhood Lead Poisoning Epidemic due to Artisanal Gold Mining in Zamfara, Nigeria 2014.
[13] *Id.*
[14] von Lindern et al., *supra* note 8.

completed in July of 2010 and more than 100 children received chelation treatment.[15] By September 2010, the remediation together with the suspension and relocation of artisanal mining activities had reduced the average blood lead level of children entering treatment from 173µg/dl to 86µg/dL.[16] Mortality rates, which had exceeded 43% of young children from January through May 2010, were reduced to less than 2% by July.[17]

During the months of June and July 2010, five more villages, Abare, Sunke, Tungar Daji, and Duza in Anka LGA, and Tungar Guru in Bukkuyum LGA, were identified as having had significant artisanal gold mining activities using the same lead-rich ores and unsafe practices. In mid-September 2010, Phase II commenced with soil and mining waste remedial activities at the five villages using the same protocols established in the June/July 2010 cleanup. This phase was conducted with funding from the United Nations (UN) Central Emergency Response Fund (CERF), administered through UNICEF in collaboration with the Zamfara State government, the two LGAs, and local Emirates. Significant additional monetary and in-kind contributions came from the Zamfara Ministry of Environment (ZMOE), MSF, TerraGraphics (TG), and Blacksmith Institute to supplement the CERF funding to bring the second phase to completion. Most of the work was accomplished by workers from ZMOE, the LGAs, and the affected villages, using local suppliers and equipment. TerraGraphics provided technical guidance for the cleanup and built local capacity through technical skills and project management training throughout the project.

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[15] Tirima et al., *supra* note 12.
[16] *Id.*
[17] MSF, *Lead Poisoning Crisis in Zamfara State, Northern Nigeria: MSF Briefing Paper*, (May 2012), *available at* http://www.doctorswithoutborders.org/sites/usa/files/Lead Poisoning Crisis in Zamfara State Northern Nigeria.pdf

By fall 2010, it also had become clear that even more villages were experiencing similar contamination and lead poisoning problems. TerraGraphics and ZMOE conducted further environmental surveys. Most distressing was the finding of extensive mineral processing in Bagega town, Anka LGA, with a population exceeding 7,000, including 1,500 children under age five at severe risk. Furthermore, the survey of Bagega revealed a large abandoned mineral processing area nestled between the village and a man-made regional water reservoir. Numerous artisanal enterprises had operated in this location leaving behind large volumes of highly contaminated ore tailings. TerraGraphics estimated the remedial needs in Bagega would exceed the total effort accomplished in the other seven villages already cleaned.[18] However, there were no funds remaining to carry out remediation in Bagega. Phase II was completed in March 2011, markedly reducing lead exposures for more than 6,000 individuals and making an additional 1,277 children eligible for enrollment in the MSF treatment program.[19]

Soon after completion of remedial activities, anecdotal evidence provided to the MSF field teams suggested that ore processing activities had resumed inside some of the remediated villages in Zamfara, particularly Yargalma and Abare. In May 2011, the MSF project coordinator of the Zamfara heavy metal project issued a report confirming the resumption of mining activity. The report detailed a visit to Yargalma where an MSF team was shown moderate scale unsafe processing activities.

After months with no deaths from lead encephalopathy, two children from Yargalma died in early 2011, despite treatment with Ethylenediaminetetraacetic acid (EDTA). One child had a blood lead level of 1073 µg/dL, the other 448 µg/dL. Serious neurological damages and

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[18] Tirima et al., *supra* note 12.
[19] *Id.*

death can occur at levels above 65 µg/dL. This led to an investigation into the extent of recontamination occurring in these Yargalma and also Abare. A collaborative assessment by both medical (MSF) and remediation (ZMOE and TerraGraphics) personnel revealed that a small number of individuals had resumed ore processing activities within the villages and compounds. Additionally, para-occupational exposure to lead was increasingly becoming a significant pathway to lead exposure, as mining workers were bringing lead contaminated working materials and clothing home. This discovery underscored the need for long term health promotion and education outreach programs, as well as a safer mining program that would ensure that para-occupational and occupational exposures would be managed.

In May 2012, the Nigerian Centre for Disease Control/FMOH and MSF held an international conference in Abuja, Nigeria, that brought together leading medical, environmental, and mining experts, together with government policy makers and traditional leadership to share lessons learned and best practices, and to develop a plan for immediate action. At the conference it was confirmed that there were more communities and villages in Zamfara that were severely lead poisoned, and that Bagega especially required immediate attention. It was unanimously recommended that the federal government of Nigeria should make a political commitment to address this crisis by ensuring that funds be made available immediately and spent appropriately. The Nigerian government responded in principle. The Federal Ministry of the Environment (FMOE) approved a Tripartite Proposal Funding in the amount of 850 million Naira (US$5.4M), for environmental remediation, safer mining initiatives, and further health interventions in Zamfara state. The President of Nigeria promised that these funds would be released following the conference. They were not. It took

another eighteen months of sustained advocacy and pressure by local and international media, civil society, MSF, Human Rights Watch and other NGOs to secure the release of the funds.

The Nigeria Federal Ministry of Environment commenced Phase III remediation addressing Bagega in February 2013 with TerraGraphics International Foundation (TIFO), a non-profit humanitarian successor to TerraGraphics, providing remediation oversight. Security protocols, TIFO logistics support, and all medical responses were provided by MSF. This third phase addressed a larger population and removed more contaminated waste than the combined Phase I and II efforts. Phase III remediated more than 350 contaminated residential compounds and numerous common areas, rehabilitated the former mineral processing area, and dredged the contaminated regional reservoir. Lead exposures were reduced for more than 7,000 residents; blood lead screening, medical surveillance, and chelation treatment were extended to an additional 673 children. The Nigerian governments and the affected communities are working to sustain this remedy and implement safer mining techniques. [20]

ZAMFARA LEAD POISONING DISASTER IN A GLOBAL CONTEXT

Not even windstorm, earth-tremor, or rush of water is a catastrophe. A catastrophe is known by its works; that is, to say, by the occurrence of disaster. So long as the ship rides out the storm, so long as the city resists the earth-shocks, so long as the levees hold, there is no disaster. It is the collapse of the cultural protections that constitutes the disaster proper. – Lowell Juilliard Carr[21]

[20] *Id.*
[21] Lowell Juilliard Carr, *Disaster and the Sequence-Pattern Concept of Social Change*, 38 AMERICAN JOURNAL OF SOCIOLOGY 207 (1932).

According to the WHO, a significant global burden of death, disease, and disability can be traced to environmental hazards.[22] The impacts of environmental hazards are especially felt in developing countries.[23] In sub-Saharan Africa for instance, more than one-third of deaths and disease are related to environmental hazards such as poor water quality and access, vector-borne disease, air pollution, toxic chemical exposures, climate change, and degraded urban environments.[24] WHO estimates that "every minute, five children in developing countries die of malaria or diarrhea. Every hour, 100 children die as a result of exposure to indoor smoke from solid fuels. Every day, nearly 1,800 people in developing cities die as result of exposure to urban pollution. Every month, nearly 19,000 people in developing countries die from unintentional poisonings." [25]

The linkages between the environment, poverty, and public health are well documented. Environmental hazards have been shown to impact human health, either directly, by exposing people to harmful agents, or indirectly, by disrupting life sustaining ecosystems. The WHO claims that approximately one-fourth of all global disease, and more than one-third of the burden among children, can be attributed to modifiable environmental factors. WHO further estimates that approximately 24% of all global disease burden (healthy life years lost) and 23% of all deaths (premature mortality) can be traced to the environment, with the environmental burden of diseases being 15 times greater in developing countries than in

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[22] WHO, *Health & environment: tools for effective decision-making, available at* http://www.who.int/heli/publications/brochure/en/index.html.
[23] *Id.*
[24] *Id.*
[25] Kyriaki Remoundou & Phoebe Koundouri, *Environmental Effects on Public Health: An Economic Perspective*, 6 INT J ENVIRON RES PUBLIC HEALTH 2160, 2160 (2009).

developed countries, due to differences in exposure to environmental risks and access to health care.[26]

Environmental pollution is a major source of health risk throughout the world, although risks are generally greater in developing countries where poverty, lack of investment in modern technology, and weak environmental regulation combine to cause high levels of pollution. Establishing causality between environmental pollution and health outcomes in poor and developing countries, however, can be difficult. For instance, predicting with certainty the causes and effects of environmental pollution on human health may require controlled experiments that compare people exposed to contaminants to those who are not.[27] Not only are such investigations morally troublesome, but in poor countries they can divert scarce resources away from treatment and intervention. Exposures may occur through a range of pathways and processes, and levels are often uncertain, or unknown, due to lack of monitoring. Outcomes may go undetected from poor surveillance, faulty diagnoses, or variation in response among population groups. Latency in disease manifestation, the effects of cumulative and multi-pollutant exposures, and numerous environmental and socio-economic cofactors confound associations between pollution and public health.[28]

Nevertheless, observations of human and environmental health benefits from improved or remediated environments indicate associations between contaminants, human health, and environmental impacts that can be beneficially rectified. Clearly, while intensive

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[26] WHO, *Preventing disease through healthy environments: Towards an estimate of the environmental burden of disease*, *available at* http://www.who.int/quantifying_ehimpacts/publications/preventingdisease/en/index.html.
[27] Yohannes Mariam, *Causal Relationship between Indicators of Human Health*, the Environment and Socioeconomic Variables for the OECD Countries (Jan. 1999), *available at* http://mpra.ub.uni-muenchen.de/666/.
[28] David Briggs, *Environmental Pollution and the Global Burden of Disease*, 68 BR MED BULL 1 (2003).

human economic activity and rapid technological advancement have given humans the capacity to control some aspects of the environment, such development has also in certain contexts proven to be a threat to survival.[29] Human induced environmental disasters such as industrial explosions, mining disasters, dam failures, oil spills, nuclear energy accidents, and the dumping of toxic wastes have threatened human life and property.[30] Numerous examples are found in historic accounts and, unfortunately, these tragedies are becoming more commonplace as technology and development proceed at ever faster speeds in the poorer areas of the globe.

One of the first documented investigations to offer scientific proof that atmospheric pollution causes mortality and morbidity occurred in the Meuse Valley of Belgium in December 1930.[31] Pollutants from coke ovens, steel smelters, glass manufacturers, zinc smelters, and sulfuric acid plants, among other industries, together with unusual weather conditions produced a deadly fog. Within a few days hundreds of people fell ill, and more than 60 people died from air pollution.[32] Scientists and health investigators eventually concluded that sulfur compounds emitted into the valley precipitated the epidemic. On the basis of the amount of coal burned in industrial and domestic fires, investigators estimated that more than 60,000 kg of sulfur dioxide (SO_2) had been released during the episode. Resultant SO_2 concentrations greatly exceeded toxicity thresholds, and the sulfur oxide gases

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[29] ANGUS M. GUNN, UNNATURAL DISASTERS : CASE STUDIES OF HUMAN-INDUCED ENVIRONMENTAL CATASTROPHES (Greenwood Press 2003).
[30] *Id.*
[31] Benoit Nemery et al., *The Meuse Valley Fog of 1930: An Air Pollution Disaster*, 357 THE LANCET 704 (2001).
[32] BARBARA J. FINLAYSON-PITTS & JAMES N. PITTS JR, CHEMISTRY OF THE UPPER AND LOWER ATMOSPHERE: THEORY, EXPERIMENTS, AND APPLICATIONS 4 (Academic Press 1999).

combined with fog droplets to produce sulfuric acid mist with a particle size small enough to penetrate deeply into the lungs.

Decades later in Bhopal, India, a single accident at a Union Carbide pesticide plant resulted in what is considered one of the world's worst industrial catastrophes.[33] On the night of December 3, 1984, several toxic chemicals, including methyl isocyanate gas, leaked from the plant exposing hundreds of thousands of people to a deadly combination of toxins. Thousands died from the exposure to the deadly effluvium within a few hours and countless individuals suffered latent effects for decades.[34]

Another example comes from the Philippines. When the Marcopper Mining Corporation finished its open pit mining operations on the Philippine Island of Marinduque in the 1970s, it plugged the old pit and converted it into a disposal lake for mining wastes.[35] In March 1996, the pit's drainage tunnel fractured, discharging more than a million cubic meters of tailings into the Makulapnit-Boac (Boac) river system.[36] Low lying areas in the river basin were completely flooded, displacing hundreds of people, destroying livelihoods, and contaminating food and fresh water sources for inhabitants of the area.[37] The destruction was so catastrophic that a United Nations assessment mission termed the incident a major environmental disaster.[38]

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[33] Edward Broughton, *The Bhopal Disaster and Its Aftermath: A Review*, 4 ENVIRONMENTAL HEALTH 6 (2005).
[34] Dinesh C. Sharma, *Bhopal: 20 Years on*, 365 THE LANCET 111, 112 (2005).
[35] Ma. Eugenia Bennagen & Ramyleo Pelayo, *Philippine Mining Disaster: Counting the Cost of a Ruined River* (Economy and Environment Program for Southeast Asia (EEPSEA)) (Nov. 1998), *available at* http://idrc.org/eepsea/ev-8430-201-1-DO_TOPIC.html.
[36] *Id.*
[37] *Id.*
[38] *Id.*

These classic environmental catastrophes were associated with excessive and abusive practices by large industries in locales with weak or non-existent regulatory authorities.[39] Lessons learned from these and other episodes have led to imposition of strict environmental health protections in developed countries. They also have led to some success in inducing responsible practices among major industrial players and governments in developing regions.[40] However, on a global basis, more children are sickened and die from environmental pollutants today than ever before.[41] Much of the increase in toxic exposures to children in poor countries is associated with the proliferation of small scale artisanal industries that develop in concert with, and to support, rapid urbanization in poor countries.[42] The UNEP predicts that the combination of climate change and urbanization in developing countries over the next few decades will overwhelm the infrastructure of many cities, depriving their inhabitants of clean water, sewage treatment, pollution control, and flood protection.[43]

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[39] David Briggs, *Environmental Pollution and the Global Burden of Disease*, 68 BR MED BULL 1 (2003).
[40] Ernie Hood, *Lessons Learned? Chemical Plant Safety since Bhopal.*, 112 ENVIRONMENTAL HEALTH PERSPECTIVES A352 (2004); Edward Broughton, *The Bhopal Disaster and Its Aftermath: A Review*, 4 ENVIRON HEALTH 6, 4 (2005).
[41] Richard Fuller, *Hazardous Waste and Toxic Hotspots*, *in* TEXTBOOK OF CHILDREN'S ENVIRONMENTAL HEALTH 254 (Philip J. Landrigan & Ruth A. Etzel eds., Oxford University Press 2013).
[42] ANNETTE PRÜSS-ÜSTÜN & C. CORVALÁN, WORLD HEALTH ORGANIZATION, PREVENTING DISEASE THROUGH HEALTHY ENVIRONMENTS TOWARDS A N ESTIMATE OF THE ENVIRONMENTAL BURDEN OF DISEASE (World Health Organization 2006); Fuller, *supra* note 36.
[43] Joint UNEP/OCHA Environment Unit, *Keeping Up With Megatrends. "The Implications of Climate Change and Urbanization for Environmental Emergency Preparedness and Response* (2012) 3–11.

The recent lead poisoning outbreak in Zamfara and a similar incident in Dakar, Senegal,[44] are perhaps harbingers of a new wave of environmental harm.[45] The children of Zamfara were poisoned not directly by large industry, but by itinerant industries within their own communities and families, work pursued to eke out a meagre livelihood in the evolving global economy. This is a very different causal setting than that of past lead poisoning epidemics. Irresponsible operations of smelter and mining operations in the former Yugoslavia,[46] Australia,[47] the United States,[48] and Zambia[49] poisoned many severely in years past. Yet few childhood deaths have been associated with industrial sourced lead poisoning over the past several decades. However, in 2009, eighteen deaths were confirmed in Dakar among children of village women employed in recovering lead from battery wastes.[50] These unprecedented deaths were soon eclipsed in Zamfara in 2010, where more than 400 children died and thousands have suffered irreversible brain damage and will become life-long burdens on their impoverished communities. These deaths and morbidities resulted from lead absorption associated with artisanal waste recovery and gold ore processing in residential

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[44] IRIN, *SENEGAL: Deadly Lead Recycling Industry Cripples Dakar Neighbourhood*, IRINNEWS (Jul. 16, 2008), *available at* http://www.irinnews.org/Report/79291/SENEGAL-Deadly-lead-recycling-industry-cripples-Dakar-neighbourhood.

[45] Philippe Calain, *What Is the Relationship of Medical Humanitarian Organisations with Mining and Other Extractive Industries?*, 9 PLOS MED e1001302 (2012).

[46] L. Borgna et al., *The High Contents of Lead in Soils of Northern Kosovo*, 101 JOURNAL OF GEOCHEMICAL EXPLORATION 137 (2009).

[47] Mark P. Taylor et al., *Lessons Learned on Lead Poisoning in Children: One-Hundred Years on from Turner's Declaration*, 47 JOURNAL OF PAEDIATRICS & CHILD HEALTH 849, 850–51 (2011).

[48] DANIEL A. VALLERO, PARADIGMS LOST : LEARNING FROM ENVIRONMENTAL MISTAKES, MISHAPS AND MISDEEDS 352–54 (Butterworth-Heinemann 2005).

[49] Nicole Branan, *Mining leaves nasty legacy in Zambia*, GEOTIMES: EARTH, ENERGY AND ENVIRONMENT NEWS (Jan. 2008), *available at* http://www.geotimes.org/jan08/article.html?id=nn_zambia.html.

[50] Pascal Haefliger et al., *Mass Lead Intoxication from Informal Used Lead-Acid Battery Recycling in Dakar, Senegal*, 117 ENVIRONMENTAL HEALTH PERSPECTIVES 1535 (2009).

compounds in agricultural and fishing villages, remote from centers of industry and commerce.

The Dakar and Zamfara communities, like untold numbers of others around the world, were induced by high metals prices in the global economy to employ archaic mineral processing and recycling practices. Yet those communities were deprived of the rewards and protections afforded those who consume the products of their itinerant mining enterprises.

Loss of life due to natural and human induced disasters disproportionately affects the poorest people of the world.[51] This is true both in developing countries and in locales occupied by the poor in developed countries.[52] While economic losses related to disasters are much greater in developed countries, the amount of economic loss relative to per capita gross domestic product suffered in developing countries far exceeds the relative percentage of economic loss in well-to-do countries.[53] Evidence suggests that the poor are more vulnerable to disasters because they lack the financial wherewithal to invest in disaster prevention and response, are more likely to live in dangerous, less desirable locations, such as flood plains, river banks, steep slopes, and urban industrial districts, cannot build safe infrastructure, lack early warning systems, and have no means of evacuation.[54]

Furthermore, in the face of disaster, the poor often lack the capacity to mitigate their own suffering, let alone prevent loss of life and property. Governments in developing

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[51] INTERNATIONAL STRATEGY FOR DISASTER REDUCTION., LIVING WITH RISK : A GLOBAL REVIEW OF DISASTER REDUCTION INITIATIVES (United Nations 2004).
[52] Claude de Ville de Goyet et al., *Natural Disaster Mitigation and Relief, in* DISEASE CONTROL PRIORITIES IN DEVELOPING COUNTRIES (Dean T. Jamison et al. eds., World Bank, 2nd ed. 2006); Alice Fothergill & Lori A. Peek, *Poverty and Disasters in the United States: A Review of Recent Sociological Findings*, 32 NATURAL HAZARDS 89, 32 (2004).
[53] INTERNATIONAL STRATEGY FOR DISASTER REDUCTION., *supra* note 51.
[54] Sheridan Bartlett, *Climate Change and Urban Children: Impacts and Implications for Adaptation in Low- and Middle-Income Countries*, 20 ENVIRONMENT AND URBANIZATION 501 (2008).

countries face numerous competing priorities and are often beset with inefficiencies and systemic corruption. More often than not, disaster preparedness and response are virtually nonexistent. The Zamfara lead poisoning incident demonstrates the need to confront environmental disasters with emergency humanitarian relief, at least on a short-term basis, to save lives and minimize suffering.

Humans, Humanitarian Relief and Environmental Health

Helping others in need is not a new concept. Beneficence is a longstanding hallmark of humanity. The concept of a transnational humanitarianism underpinned by an impartial obligation to the unknown distant other, however, is a phenomenon that only emerged in the late nineteenth century. Humanitarian relief, as known today, evolved from early wound dressing and pain relief across the battlefields of the nineteenth and early twentieth centuries, to the highly professionalized and robust relief organizations that proliferated in the late twentieth century. Today, specialized areas of humanitarian response such as emergency and disaster medicine, humanitarian food aid, and displaced peoples assistance are readily found in locales ravaged by disaster. The modern humanitarian sector is characterized by many professional organizations, such as the highly visible International Committee of the Red Cross and MSF. Some organizations such as OXFAM and CARE International, which traditionally offered only short-term emergency relief, are now involved in long-term aid aimed at reducing poverty and rebuilding infrastructure. Non-governmental organizations such as Amnesty International and Human Rights Watch promote human rights in the spirit of humanitarianism. Various agencies of the United Nations provide multi-lateral humanitarian assistance and help coordinate some of the most complex emergencies across the globe.

Countless NGOs with humanitarian agendas operate in various topically specialized, geographically focused, or socio-politically technical arenas. Today, the so-called humanitarian industry is a multi-billion dollar relief sector with hundreds of thousands workers.

While there are specialized and well accepted disaster response systems in the medical field, such as MSF and organizations that offer humanitarian food relief, the broad area of environmental public health response has not enjoyed the same recognition or status. There are several reasons for this. As a discipline, environmental health is difficult to define. Even in developed countries, it remains an emerging field with a widely scattered knowledge base, requiring an expensive infrastructure to both characterize problems and implement and maintain solutions.[55] Responses to environmental public health crises are complex and multidisciplinary, drawing on the fields of clinical medicine, epidemiology, chemistry, biology, toxicology, engineering, ecology, economics, political science, law, and ethics.[56] Resolving environmental health challenges often involves corrective actions requiring remedial or restorative work that effectively augments or replaces existing infrastructure. Most major environmental remedial work around the world is conducted by large engineering and construction entities, hired by transnational firms to perform obligatory cleanups or some regulatory duty.

Many human-induced environmental pollution disasters, especially those with ties to large industries, were preventable and have known culprits. In these cases, it is generally felt that the polluter should pay and intervention by humanitarians might encourage irresponsible

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[55] JEROME O. NRIAGU, ENCYCLOPEDIA OF ENVIRONMENTAL HEALTH (2011).
[56] *Id.*

behavior.[57] As such, environmental remediation is not often seen as a part of the larger mission of humanitarians, but rather as a commercial enterprise or regulatory obligation.[58]

According to the WHO, "[e]nvironmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments."[59] This definition lends well to development aid or programmatic initiatives to improve infrastructure and capacity to prevent or mitigate catastrophic events. However, when confronted with environmental public health emergencies that necessitate immediate coordination of an aggressive agenda under dire circumstances in poor and developing nations, environmental public health humanitarian response becomes both daunting and requisite. The solutions generally require sophisticated and coordinated interdisciplinary response. Necessary resources are likely housed in international for-profit firms and western government institutions. It becomes difficult to distinguish where emergency relief ends and restoration, prevention, and mitigation begin. In-country resources and expertise are likely poorly developed, overwhelmed, or suffer from inefficiencies or systemic corruption.

Unlike the clinical medical strategies of identifying, isolating and treating the pathogen, the major determinants of (and solutions to) environmental public health crises often depend on such nebulous factors such as environmental changes, access to water and

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[57] Calain, *supra* note 45.
[58] Ronald E. Hill, A Comprehensive Analysis of the Environmental Remediation Industry (Jun. 2000) (unpublished Thesis, Naval Postgraduate School), *available at* https://archive.org/details/comprehensiveana00hill
[59] WHO, *Environmental health*, *available at* http://www.who.int/topics/environmental_health/en/.

sanitation, human economic activity, and population dynamics.[60] In our modern humanitarian context that celebrates professional specialization, it becomes arduous to carve out a space for a multidisciplinary behemoth such as environmental public health.[61]

Still, environmental health in the context of global emergencies has not gone entirely unnoticed. In 2007, a joint initiative between UNEP, the United Nations Office for the Coordination of Humanitarian Affairs, and Green Cross International developed the Green Star Award.[62] The goal of the award is three fold: "to raise awareness of environmental emergencies; to encourage increased international efforts to prevent, prepare for and respond to such emergencies; to emphasize the connection between environmental impacts of disasters and emergencies and the consequences for affected populations and providers of humanitarian assistance."[63] The award recognizes individuals and organizations that have made remarkable efforts to prevent, prepare for, and respond to environmental disasters around the world.[64] In 2011 this biannual award went to MSF, TerraGraphics, and Blacksmith Institute for their coordinated response to the lead poisoning outbreak in Zamfara.[65]

The pace at which environmental emergencies and issues surrounding environmental health are making their way onto the humanitarian center stage thus makes this an opportune juncture for exploring whether an ethical framework can be crafted to provide guidance for

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[60] NRIAGU, *supra* note 55.
[61] Philippe Calain, *The Interaction between Humanitarian Non-Governmental Organisations and Extractive Industries: A Perspective from Médecins Sans Frontières*, 94 INTERNATIONAL REVIEW OF THE RED CROSS 1115 (2012).
[62] UNEP, Press Releases May 2011 - Green Star Awards honour environmental heroes working in disasters - United Nations Environment Programme (UNEP), *available at*http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=2641&ArticleID=8741&l=en&t=long.
[63] *Id.*
[64] *Id.*
[65] *Id.*

environmental disaster relief practitioners. This paper proposes such an ethic. We advance an anthropocentric environmental humanitarian ethic that draws elements from a variety of moral theories. An attempt is made to distinguish environmental humanitarianism from environmental ethics and environmental justice to avoid identity crises and the temptation to create a hierarchy of victims. Environmental public health relief comes at a time that humanitarianism in general is at crossroads. While humanitarian organizations do remarkable relief work in extremely difficult and complex circumstances, there is growing criticism that these well-meaning actors have succumbed to 1) corporate like tendencies of inter and intra-agency competition, 2) an obsession with raising funds by any means necessary, including objectification of suffering, and 3) a lack of accountability characterized often by the appearance of acting in their own best interests rather than foremost to better the victims of disaster.[66] Our analysis means to refocus the discourse of environmental public health relief on those ethical underpinnings that promote humanitarian ends in this evolving discipline. The Zamfara lead poisoning epidemic will provide the foundational case for our analysis and development of an ethic of environmental humanitarianism.

A Brief History of Humanitarianism

"Humanitarianism consists in never sacrificing a human being to a purpose."[67]

– Albert Schweitzer

Disasters and the idea of extending kindness, sympathy, and help to those in distress are as old as humanity itself. Compassion and the charitable impulse to bring succor to suffering is woven in the fabric of humanity. Notions of obligation to help the needy are

[66] The Lancet, *Growth of Aid and the Decline of Humanitarianism*, 375 LANCET 253 (2010).
[67] Winthrop Sargeant, *Albert Schweitzer*, 27 LIFE MAGAZINE, Jul. 25, 1949, at 74, 82.

found in ancient religious and philosophical writings. Throughout history, humanitarian sentiments have inspired protection of human dignity as demonstrated by movements such as the antislavery campaigns of the eighteenth century and the establishment of international human rights law following World War II.[68] Nevertheless, the notion of humanitarianism has been vulnerable to abuse and in some cases used as subterfuge for hegemony and colonization.[69]

During the Berlin Conference to partition and colonize Africa in the late 1800s, King Leopold II of Belgium was granted control over the Congo partly because he portrayed himself as a humanitarian and philanthropist intent on civilizing Africa through religion and commerce.[70] However, King Leopold's occupation of the Congo would become a brutal period of human repression, abuse, and exploitation.[71] He was not alone as a patron of humanitarian misdeeds. For centuries, missionaries, explorers, and cohorts of European government representatives went to Africa ostensibly to help Africans recover from the ravages of slavery and barbarism. However, by the late 1920s all of Africa, excepting Ethiopia and Liberia, had fallen under some form of colonial rule.[72] The misconceptions of humanitarianism among European powers in the nineteenth century ended up promoting international human rights abuse and gross miscarriages of global justice.

Modern conceptions of professionalized, independent, and impartial humanitarianism can be traced to a Swiss businessman, Henri Dunant. In 1859 Dunant witnessed firsthand the

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[68] RICHARD WILSON & RICHARD D. BROWN, HUMANITARIANISM AND SUFFERING: THE MOBILIZATION OF EMPATHY (Cambridge University Press 2009).
[69] MICHAEL N. BARNETT, EMPIRE OF HUMANITY: A HISTORY OF HUMANITARIANISM (Cornell University Press 2011).
[70] ADAM. HOCHSCHILD, KING LEOPOLD'S GHOST: A STORY OF GREED, TERROR, AND HEROISM IN COLONIAL AFRICA (Houghton Mifflin 1998).
[71] *Id.*
[72] F.P. MILLER ET AL., COLONISATION OF AFRICA (VDM Publishing House Ltd. 2009).

horrors of war caused by the Battle of Solferino in present day Italy. Traveling on business to meet Napoleon III, Dunant arrived in Solferino the evening following nine hours of brutal combat that would prove decisive in ending the Second Italian War of Independence. He found a battlefield littered with more than 30,000 wounded, dying, or dead Austrian, Italian, and French soldiers. Most were left unattended as each army extended medical attention only to its own injured.[73] For several days Dunant devoted himself to the treatment and care of the wounded by mobilizing civilians to give aid without discrimination.[74] At the same time he negotiated with the armies not to interfere with his work. Upon his return to Geneva Dunant wrote: "Would there not be some means, during a period of peace and calm, of forming relief societies whose object would be to have the wounded cared for in time of war by enthusiastic, devoted volunteers, fully qualified for the task?"[75] Four years later, Dunant founded the International Committee on the Red Cross (ICRC) in Geneva based upon the principles of impartiality and neutrality. It is commonly agreed that Dunant laid the foundation for the medical non-governmental humanitarian organizations that exist today, such as MSF and International Medical Corps.[76]

Following the creation of the ICRC, other humanitarian organizations emerged in response to crises caused by nineteenth and twentieth century wars. Save the Children was founded in 1919 in the aftermath of World War I.[77] Humanitarian crises resulting from World War II lead to the formation of relief organizations such as Catholic Relief Services, the

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[73] CHARLOTTE GRAY, HENRY DUNANT: FOUNDER OF THE RED CROSS, THE RELIEF ORGANIZATION DEDICATED TO HELPING SUFFERING PEOPLE ALL OVER THE WORLD (G. Stevens 1989).
[74] *Id.*
[75] HENRY DUNANT & AMERICAN NATIONAL RED CROSS. DISTRICT OF COLUMBIA CHAPTER., A MEMORY OF SOLFERINO (The American National Red Cross 1959).
[76] Michael Barnett, *Humanitarianism Transformed*, 3 PPS 723 (2005).
[77] JENNIFER NAULT, SAVE THE CHILDREN (Weigl Publishers Inc. 2003).

International Rescue Committee, CARE International, and Oxfam.[78] United Nations agencies including the United Nations Children's Fund (UNICEF), United Nations High Commission on Refugees, United Nations World Food Program, and the Office for Coordination of Humanitarian Affairs emerged from the ashes of World War II. These agencies heralded an era of global multilateral commitment to humanitarian relief and protection of human rights.[79] Also during the period following World War II, many relief organizations originally founded to provide relief and reconstruction in Europe began to look outward to other regions of the world.[80]

The evolution of humanitarianism was founded on the premise, formalized by the ICRC in 1965, that "all humans in life-threatening situations have a right to receive assistance."[81] This principle and six others - impartiality, neutrality, independence, voluntary service, unity, and universality – were proposed by Swiss jurist Jean Simon Pictet, an expert in international humanitarian law and Vice President of the ICRC, and adopted by the Red Cross movement in 1965[82] in the form of a document called "Fundamental Principles of the Red Cross.[83] The ethical guiding principles of the ICRC have been embraced in some fashion by many relief organizations whose goals are to provide assistance independently and impartially. Humanitarian practitioners, such as MSF, who have adopted the traditional

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[78] DAVID. RIEFF, A BED FOR THE NIGHT : HUMANITARIANISM IN CRISIS (Simon & Schuster 2002).
[79] JOHN ALLPHIN MOORE & JERRY PUBANTZ, ENCYCLOPEDIA OF THE UNITED NATIONS (Infobase Publishing 2008).
[80] BARNETT, *supra* note 69. Empire of Humanity
[81] KENNETH A. REINERT ET AL., THE PRINCETON ENCYCLOPEDIA OF THE WORLD ECONOMY: I-W 40 (Princeton University Press 2009).
[82] YVES BEIGBEDER, THE ROLE AND STATUS OF INTERNATIONAL HUMANITARIAN VOLUNTEERS AND ORGANIZATIONS: THE RIGHT AND DUTY TO HUMANITARIAN ASSISTANCE (Martinus Nijhoff Publishers 1991).
[83] BARNETT, *supra* note 69, at 137.

ICRC's model of humanitarianism, are generally characterized as Dunantist organizations. Dunantists promote a strict separation between humanitarianism and strategic long-term economic development aid. In contrast, "Wilsonian" humanitarian organizations (named after US President Woodrow Wilson) see their role as an extension of, or at least compatible with, their country's world view and foreign policy objectives.[84]

Historically, the primary objectives of humanitarian action have been short-term in nature, namely to save lives, alleviate suffering, and maintain human dignity during and in the aftermath of human-made crises and natural disasters. More recently, some relief organizations have adopted longer term approaches aimed at post-disaster rehabilitation, prevention, and strengthening preparedness for the occurrence of disasters.[85] For example, OXFAM, Save the Children, and CARE International not only provide emergency relief but are also involved in poverty mitigation activities in developing countries.[86]

Concurrent with the end of the Cold War in the early 1990s came a new global phenomenon of twenty-four hour news coverage. Wars, atrocities, and human suffering never seen before in Western homes were now accessible to people with television remote control.[87] The horrors of internal wars in Somalia, Rwanda, and Kosovo were witnessed in real time in living rooms across the globe. The devastation from natural calamities such as the 2004 Indian Ocean tsunami, the earthquake in Haiti, and recurrent floods in Pakistan became all too

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[84] Max Stephenson & Marcy Schnitzer, *Exploring the Challenges and Prospects for Polycentricity in International Humanitarian Relief*, 52 AMERICAN BEHAVIORAL SCIENTIST 919 (2009).
[85] Abbey Stoddard, *Humanitarian NGOs: Challenges and Trends*, 12 HUMANITARIAN POLICY GROUP BRIEF (HPG Briefs, 2003).
[86] *Id.*
[87] Etyan Gilboa, *The CNN Effect: The Search for a Communication Theory of International Relations*, 22 POLITICAL COMMUNICATION 27 (2005).

close in part due to the intense and easily accessible media coverage.[88] It is during this post-Cold War era that humanitarian assistance grew dramatically, both in numbers of organizations and budgets.[89] Internationally, the humanitarian aid budget leapt from two billion to six billion US dollars from 1990 to 2000. Today, it is estimated that more than eighteen billion dollars from private and government donors are available for humanitarian assistance worldwide. In addition, the humanitarian sector now employs over 200,000 personnel, almost twice the number of aid workers from a decade ago.[90]

All Humanitarianisms Are Not the Same

The term humanitarianism is vague, fraught with ambiguities, and means different things to different people.[91] For the purpose of this paper, humanitarianism contemplates actions to save lives, alleviate suffering, and protect human dignity during and in the immediate aftermath of emergencies.[92] This definition is underpinned by the Dunantist principles of humanity, neutrality, impartiality, and independence, as ratified by the ICRC in 1965.[93] Humanitarian action as understood here involves short-term response, not adoption of longer-term development programs designed to rebuild the infrastructure of the affected. While it is problematic to draw the line where one form of aid ends and another begins, humanitarian relief is intended to help remove immediate threats to life and livelihoods and to ease suffering.

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[88] BARNETT, *supra* note 71.BARNETT, *supra* note 73. Empire of Humanity
[89] *Id.*
[90] *Id.*
[91] Antonio Donini, *Humanitarianism in the 21st Century*, HUMANITAIRE. ENJEUX, PRATIQUES, DÉBATS (2010).
[92] *Id.*
[93] *Id.*

This paper also follows the common distinction between humanitarian intervention and humanitarian relief. Humanitarian intervention, as defined by the Danish Institute of International Affairs, is "coercive action by states involving the use of armed force in another state without the consent of its government, with or without authorization from the United Nations Security Council, for the purpose of preventing or putting to halt gross and massive violations of human rights or international humanitarian law."[94] The analysis in this paper favors traditional Dunantist humanitarian *relief*. It extends to provision of material relief assistance and services such as medicines, shelter, and water, provision of emergency food aid, and relief coordination, protection, and support services.

While the Dunantist principles of impartial, neutral, and universal assistance are hailed as foundational in today's humanitarian circles, criticism has nonetheless been levied at humanitarianism recently for having succumbed to principlism.[95] Some also criticize humanitarianism on the premise that many human-made disasters have political roots and that actions to mitigate the circumstances of suffering in such contexts has unintended socio-political, economic, or even military ramifications.[96] For example, humanitarian assistance can create false economies when the presence of aid agencies in impoverished communities increases the cost of local services and rents that are not of long-term benefit to a community, especially when the aid agencies depart.[97] Humanitarian aid, especially in Africa, has also been charged with prolonging military conflicts by inadvertently providing material support

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[94] DANSK UDENRIGSPOLITISK INSTITUT (1995-), HUMANITARIAN INTERVENTION: LEGAL AND POLITICAL ASPECTS. (Danish Institute of International Affairs 1999).
[95] K. Danner Clouser & Bernard Gert, *A Critique of Principlism*, 15 J MED PHILOS 219 (1990).
[96] FIONA. TERRY, CONDEMNED TO REPEAT?: THE PARADOX OF HUMANITARIAN ACTION (Cornell University Press 2002).
[97] Dale Jamieson, *Duties to the Distant: Aid, Assistance, and Intervention in the Developing World*, 9 JOURNAL OF ETHICS 151 (2005).

and bargaining power for competing factions.[98] Another criticism raised against humanitarianism is that since there is no standard for ranking disasters as to which deserve humanitarian response, a shadow of arbitrariness falls over all such determinations. Further, some allege that the socio-political context within which humanitarian aid is administered can often force a situation where assistance is given or withheld in order to meet objectives other than simply serving the needy without partiality.[99] Another charge against humanitarian assistance is that it can sabotage agency, creating dependency on the part of the recipients.[100] These criticisms make the question of whether humanitarian aid organizations have had an overall positive outcome quite pressing in recent times.[101] Nonetheless, in spite of these recent criticisms, the international humanitarian sector has continued to grow dramatically in the number of participants and budget.[102]

Disasters and Emergencies

The International Agreed Glossary of Basic Terms Related to Disaster Management defines a disaster as a "serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources. Disasters are often classified according to their cause (natural or

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[98] LINDA POLMAN ET AL., THE CRISIS CARAVAN: WHAT'S WRONG WITH HUMANITARIAN AID? (Metropolitan Books 2010); RIEFF, *supra* note 78.
[99] Fiona Fox, *New Humanitarianism: Does It Provide a Moral Banner for the 21st Century?*, 25 DISASTERS 275 (2001).
[100] The Lancet, *supra* note 66.
[101] Keith Horton, *Aid Agencies: The Epistemic Question*, 28 JOURNAL OF APPLIED PHILOSOPHY 29 (2011).
[102] BARNETT, *supra* note 69.

manmade).”[103] Disasters occur when a critical mass of people are left vulnerable to hazards that threatens to take their lives, cause gross harm, or destroy their livelihoods. These events become emergencies when the onset is sudden and overwhelming.[104]

According to annual data compiled by the Centre for Research on the Epidemiology of Disasters (CRED) of the Université catholique de Louvain in Belgium, the year 2010 was one of the deadliest for natural disasters in recent history. CRED recorded more than 300 natural disasters affecting more than 200 million people, claiming the lives of more than one quarter million individuals, with nearly $110 billion lost.[105] The United Nations predicts that this trend will exacerbate in the coming years due to global climate change and urbanization. Curiously, the CRED report of 2010 limits the category “disaster” to include only geophysical, meteorological, hydrological, and climatological calamities. It leaves out biological or chemical disasters, i.e., those caused by the exposure of living organisms to germs or toxic substances. This underscores the blurriness of the line between natural and human-made disasters. It could be argued that some of the so-called natural disasters are actually human caused, insofar as they reflect consequences of human action that has impacted natural forces or altered natural conditions. For example, locating wards in New Orleans in geographically vulnerable areas historically has imperiled lives and property when hurricanes or other

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[103] UN Department of Humanitarian Affairs, *Internationally Agreed Glossary of Basic Terms Related to Disaster Management*, RELIEFWEB (Jan. 1992), *available at* http://reliefweb.int/report/world/internationally-agreed-glossary-basic-terms-related-disaster-management.

[104] BENJAMIN. WISNER ET AL., ENVIRONMENTAL HEALTH IN EMERGENCIES AND DISASTERS: A PRACTICAL GUIDE (World Health Organization 2002).

[105] D. Guha-Sapir, F. Vos , R. Below and S. Ponserre. *Annual Disaster Statistical Review 2010: The Numbers and Trends. Brussels*: CRED; (2011), *available at* http://www.cred.be/sites/default/files/ADSR_2010.pdf.

tropical storms have touched down in the area.[106] Overpopulation and consumption patterns have resulted in overexploitation of natural resources, pollution, and accumulation of waste in the environment. Global climate change, which has been attributed to both anthropogenic and natural processes, is said to be one of the culprits in the increased incidence and intensity of hurricanes, floods, and droughts.[107] Urbanization in coastal cities with insufficient infrastructure puts more and more people in harms' way every day.

The terms disaster and emergency are often used interchangeably.[108] However, emergency is best situated within the context of disaster response[109]. Response activities during the emergency phase of a disaster are aimed at saving lives and alleviating suffering.[110] The emergency phase often necessitates that normal procedures be suspended in the short-term and extra-ordinary measures be undertaken to alleviate the acute impacts of a disaster. In many resource scarce settings, assistance during emergency phases comes in the form of relief aid, often administered under the Dunantist principles of humanity (needs-based), independence and neutrality.[111] While most natural and conflict precipitated disasters receive relief aid, human caused environmental disasters such as the Bhopal incident often are left unattended by the international humanitarian community. Perhaps this is because there is the

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[106] Clarence L. Mohr & Lawrence N. Powell, *Through the Eye of Katrina: The Past as Prologue? An Introduction*, 94 THE JOURNAL OF AMERICAN HISTORY 693 (2007).
[107] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS: CONTRIBUTION OF WORKING GROUP I TO THE THIRD ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (John Theodore Houghton ed., Cambridge University Press 2001).
[108] STEPHEN DOVERS & JOHN HANDMER, THE HANDBOOK OF DISASTER AND EMERGENCY POLICIES AND INSTITUTIONS 8 (Taylor & Francis 2012).
[109] *Id.* at 83–122.
[110] Global Humanitarian Assistance, *Defining humanitarian assistance*, GLOBAL HUMANITARIAN ASSISTANCE, *available at* http://www.globalhumanitarianassistance.org/data-guides/defining-humanitarian-aid.
[111] *Id.*

view that disasters resulting from technological failure or extractive industries' negligence fall within the purview of statutory agencies.[112] However, the Zamfara environmental health public disaster clearly demonstrated that the statutory authorities were overwhelmed beyond their day to day capacity and without humanitarian relief many more children would have died. In addition, the Zamfara response brought the issue to the forefront of key international actors.

The lead poisoning outbreak in Zamfara underscores the need for a bold anthropocentric ethic in order to lay the foundation for meaningful humanitarian responses this type of environmental public health disaster. Environmental ethics and environmental justice seem inadequate to provide such a foundation. They may, in some respects, be competing paradigms that might cloud the need to have a clear path to humanitarian responses to environmental catastrophes.

SITUATING HUMANITARIANISM ALONGSIDE ENVIRONMENTAL ETHICS AND JUSTICE

A central concern in defining humanitarianism in the context of environmental ethics is resolving the ecocentric and anthropocentric views of the moral relationship between humans and the environment.[113] As a formal area of philosophical investigation, questions such as whether nature holds absolute and nonnegotiable value, whether non-human aspects of nature have rights, and whether the environment is entitled to moral standing not derived from human interests is relatively recent. Among others, the works of Aldo Leopold and Arne Næss are considered foundational in modern environmental ethics. Leopold's "Land Ethic,"

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[112] Susan Engel & Brian Martin, *Union Carbide and James Hardie: Lessons in Politics and Power*, 20 GLOBAL SOCIETY 475, 475–80 (2006).
[113] See PAUL W. TAYLOR, RESPECT FOR NATURE: A THEORY OF ENVIRONMENTAL ETHICS (Princeton University Press 1986).

published in 1949 in his *A Sand County Almanac*, argues that modern society needs a new ethic toward nature.[114] The ethic Leopold proposed, often today classed as an ecocentric ethic, asserts that, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."[115] Leopold argued that nature has intrinsic worth that we can best love and appreciate when we learn to "think like a mountain."[116] Another prominent figure in environmental ethics, Arne Næss, posited that the root cause of environmental problems is the anthropocentric approach toward development.[117] To arrest human destruction of nature, Næss suggested that humans ought to view themselves as an integral part of, not apart from, nature.[118] This constitutes a core principle of the philosophy of deep ecology, where humans and nature are said to have equal right to live and thrive. The Leopoldian land ethic and Naess' deep ecology do not represent the entire spectrum of environmental ethics. They do, however, form the foundational backdrop for understanding how the human-nature relationship is generally conceived in contemporary environmental ethics.

While environmental ethics is not in general misanthropic, some interpretations of the land ethic, deep ecology, or other ecocentric norms have stimulated views that harbor misanthropic sentiments, sometimes pitting environmental ethics against humanitarian

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[114] ROBIN ATTFIELD, ENVIRONMENTAL ETHICS: AN OVERVIEW FOR THE TWENTY-FIRST CENTURY (2003).
[115] ALDO LEOPOLD, A SAND COUNTY ALMANAC, AND SKETCHES HERE AND THERE (Oxford University Press 1968).
[116] *Id.*
[117] Arne Naess, *The Shallow and the Deep, Long-range Ecology Movement. A Summary*, 16 INQUIRY 95 (1973).
[118] DAVID PEPPER, MODERN ENVIRONMENTALISM: AN INTRODUCTION (Routledge 1996).

ideals.[119] Given this, philosophies of environmental justice began late in the twentieth century alongside environmental ethics.

The concerns of environmental justice extend to matters such as the Warren County, North Carolina, hazardous waste landfill controversy. In 1982 the State of North Carolina identified a low-income, predominantly African American community in Warren County as the site for a new hazardous waste facility where polychlorinated biphenyls (PCB)-contaminated soils from fourteen counties in the state would be landfilled.[120] Environmental and civil rights activists staged numerous peaceful, non-violent demonstrations protesting the landfill siting as an unfair and prejudiced action.[121] These events elevated the issue of discrimination in locating waste facilities to a national level.[122] A 1983 Federal General Accounting Office study showed strong bias in landfill siting, with three of every four waste dumps located near predominantly minority communities.[123] In 1987, groundbreaking research by the United Church of Christ's Commission for Racial Justice confirmed that race is the single most significant factor in the co-location of low-income housing and hazardous waste facilities. The study found that three of every five African Americans and Hispanics lived in community housing near toxic waste dumps.[124] From events and studies such as these

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[119] Charles S. Brown, *5 Beyond Intrinsic Value: Undermining the Justification of Ecoterrorism*, 66 AMERICAN JOURNAL OF ECONOMICS AND SOCIOLOGY 113 (2007).
[120] EILEEN MCGURTY, TRANSFORMING ENVIRONMENTALISM: WARREN COUNTY, PCBS, AND THE ORIGINS OF ENVIRONMENTAL JUSTICE (Rutgers University Press 2009).
[121] *Id.*
[122] *Id.*
[123] GAO, *Natural Resources and Environment: Siting of Hazardous Waste Landfills and Their Correlation With Racial and Economic Status of Surrounding Communities,* (Jun. 1, 1983), *available at* http://www.gao.gov/assets/150/140159.pdf.
[124] United Church of Christ. Commission for Racial Justice, *Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites* (1987), *available at* http://www.ucc.org/about-us/archives/pdfs/toxwrace87.pdf

the concepts "environmental racism" and "environmental justice" were birthed.[125] In a narrow sense, environmental justice may be described as an anthropocentric ethic based on the general principles of social equity and human welfare. However, environmental justice need not be dismissive of environmental ethics or moral concern for the environment. At its core, environmental justice seeks to identify and correct disproportionate adverse environmental burdens placed on marginalized communities. Underpinning environmental justice are conceptions of distributive, procedural, and rectificatory justice, and human rights.[126]

The US Environmental Protection Agency (USEPA) defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[127] Fair treatment according to the USEPA means that "no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies."[128] The USEPA's reference to "fair treatment" seems to contemplate distributive justice, or the fairness by which the risks of environmental hazards are distributed among the population.[129] Meaningful involvement means that "people have an opportunity to participate in decisions about activities that may affect their environment and/or health; the

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[125] Rachel D. Godsil, *Remedying Environmental Racism*, 90 MICHIGAN LAW REVIEW 394 (1991).
[126] CLIFFORD RECHTSCHAFFEN ET AL., ENVIRONMENTAL JUSTICE : LAW, POLICY & REGULATION (Carolina Academic Press 2009).
[127] U.S. EPA, *Environmental Justice*, Announcements & Schedules, *available at* http://www.epa.gov/environmentaljustice/.
[128] U.S. EPA, *How Does EPA define Environmental Justice?, available at http://compliance.supportportal.com/link/portal/23002/23009/Article/32790/How-Does-EPA-define-Environmental-Justice.*
[129] Alice Kaswan, *Environmental Justice: Bridging the Gap between Environmental Laws And'justice'*, 47 AMERICAN UNIVERSITY LAW REVIEW (1997).

public's contribution can influence the regulatory agency's decision; their concerns will be considered in the decision making process; and the decision makers seek out and facilitate the involvement of those potentially affected."[130] This seems to suggest that evaluation of environmental justice goes beyond the examination of distribution of hazards, to contemplate the notion that procedures used to determine fairness must also be just and provide corrective actions where warranted. There is a concern among environmental justice activists that the equity in distribution outcomes might be influenced by the process through which decisions are made.[131] This concern regarding the fairness of procedures is sometimes referred to as procedural justice and the corrective actions as rectificatory justice.[132]

Environmental justice is also viewed as a human rights issue. Kristin Shrader-Frechette argues that basic human rights are violated when environmental injustices and the resultant harm exceeds certain "thresholds" that threaten people's security.[133] If pollution causes significant increases in deaths or serious injuries, especially if those harms are inequitably distributed, then a violation of human rights has taken place.[134] While Shrader-Frechette does not provide any legal framework to address environmental injustices, she posits that to the degree that citizens have participated in, or unfairly benefitted from, social institutions that have helped cause life-threatening or rights-threatening environmental injustice, the culprits have *prima facie* duties to either stop their participation in these

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[130] *Id.* at 238.
[131] Bruno S. Frey & Felix Oberholzer-Gee, *Fair Siting Procedures: An Empirical Analysis of Their Importance and Characteristics,* 15 J. POL. ANAL. MANAGE. 353 (1996).
[132] RECHTSCHAFFEN ET AL., *supra* note 126.
[133] Kristin Shrader-Frechette, *Human Rights and Duties to Alleviate Environmental Injustice: The Domestic Case,* 6 JOURNAL OF HUMAN RIGHTS 107 (2007).
[134] *Id.*

institutions, provide compensation, or help reform the institutions.[135] While Shrader-Frechette and others generally agree that the environmental justice movement started in the United States, in recent decades the concepts of environmental justice have gone global.[136] On a global scale, Francis Adeola contends that the unabated North-to-South flow of hazardous wastes represents a "transnational environmental injustice hypothesis."[137]

The foregoing conceptions of environmental justice seem compatible with humanitarianism as conveyed in this paper because of the common thread of duty to do something to improve the human condition. Perhaps the difference between humanitarianism and environmental justice is that the former is founded on a sentiment of morality and imperative of beneficence to mitigate catastrophes, while the latter provides a legal framework to prevent or redress particular acts of injustice.

ETHICS OF CARE AND JUSTICE: RECONCEPTUALIZING HUMANITARIANISM

As Justice gives every Man a Title to the product of his honest Industry, and the fair Acquisitions of his Ancestors descended to him; so Charity gives every Man a Title to so much of another's plenty, as will keep him from extreme want, where he has no means to subsist otherwise. – John Locke[138]

Some of the earliest conceptions of an ethic of care were articulated in the second half of the twentieth century by feminist theorists such as Carol Gilligan, Nel Noddings, and

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[135] *Id*.
[136] David Schlosberg, *Reconceiving Environmental Justice: Global Movements And Political Theories*, 13 ENVIRONMENTAL POLITICS 517 (2004).
[137] Francis O. Adeola, *Environmental Injustice and Human Rights Abuse: The States, MNCs, and Repression of Minority Groups in the World System*, 8 HUMAN ECOLOGY REVIEW 39 (2001).
[138] John Locke, Two Treatises of Government (206) (Peter Laslett, ed. 1960) (1690)

Elizabeth Bartlett, when they began questioning the assumptions behind many of the traditional ethical theories, especially theories of justice as conceived by Immanuel Kant and John Rawls.[139] Gilligan was the first to express the idea that women experience moral development differently than men. In her account, women's conceptions of morality are founded on caring and responsibility for others, rather than on impartial, objective, and distant rights and rules.[140] While Tom Beauchamp and James Childress in their analysis of biomedical ethics do not necessarily concur that caring is uniquely a female trait, they agree that human relationships involving vulnerable persons should be governed by an "attached attentiveness to need" rather than a "detached respect for rights."[141] In their view, emotions play a central "cognitive role" that helps account for responses to situations that are not easily grasped by merely invoking a "justice perspective."[142]

Following Gilligan's foundational work in women's moral development a debate unfolded between ethics of care and ethics of justice. Some came to see each ethic as occupying its own discrete space while others argued that these two general approaches to ethics should not be seen as occupying polar ends. Rather, they can be tied together in complementarity.

Virginia Held is one who argues against convergence of the two ethical approaches. Held maintains that while traditional conceptions of justice are embedded within moral and political conceptions of individual rights, equality, and universal law, ethics of care

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[139] MICHAEL A. SLOTE, THE ETHICS OF CARE AND EMPATHY (Taylor & Francis 2007).
[140] CAROL. GILLIGAN, IN A DIFFERENT VOICE: WOMEN'S CONCEPTION OF THE SELF AND OF MORALITY (Harvard Educational Review 1977).
[141] TOM L. BEAUCHAMP & JAMES F. CHILDRESS, PRINCIPLES OF BIOMEDICAL ETHICS (Oxford University Press 2009).
[142] *Id.*

contemplate relations, equity, and responsibility to others.[143] She draws a clear distinction between ethics of care and theories of justice that stem from dominant moral theories, such as Kantian moral theory, Rawls' theory of justice, utilitarianism, or virtue ethics, as follows:

> [A]n ethic of justice focuses on issues of fairness, equality, and individual rights, seeking impartial and abstract principles that can be applied consistently to particular cases. Individual persons are seen as instances of the general and timeless conception of person. In contrast, the ethics of care focuses on attentiveness to context, trust, responding to needs, and offers narrative nuance; it cultivates caring relations. Persons are seen as enmeshed in relations and unique. An ethic of justice seeks fair decisions between competing individual rights and interests. The ethics of care sees the interests of carers and cared-for as importantly shared. While justice protects equality and freedom from interference, care values positive involvement with others and fosters social bonds and cooperation.[144]

In order to provide the full normativity of an ethics of care, Held cautions that the ethic of care should not be understood as a naturalized ethic. Rather, practitioners of caring "must be taken to be moral subjects not reducible to the objects of scientific description."[145] To Held, this understanding of morality has an important global dimension. She asserts that while ethics of care have been associated most often with a narrow view of moral theory, specifically with moral relationships in the private sphere, care ethics has potential for wider

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[143] Virginia Held, *Care and Justice in the Global Context*, 17 RATIO JURIS 141 (2004).
[144] *Id.* at 144.
[145] *Id.* at 145.

informative and transformative applications to contemporary problems in international relations and global issues.[146]

Annette Baier,[147] contrary to Held, attempts to reconcile caring and justice in a complimentary relationship. While discussing Gilligan's work, Baier concludes that care integrated with justice will result in a positive revision of morality. She underscores the importance of justice by affirming that "there is little disagreement that justice is a social value of very great importance, and injustice an evil."[148] Given that care is also critical, Baier argues that "justice and care should be harmonized with each other." Harmonization would preserve and augment the value of each.[149] To Baier, the "harmonization of justice and care is the same as the harmonization of man and woman. The cooperation of the two will form something that will be beneficial for both parties."[150]

Elizabeth Ann Bartlett argues that it is time to move beyond the question of either/or when it comes to the ethics of justice and care.[151] Bartlett finds a "fruitful" interrelationship between care and justice in Albert Camus's "rebellion ethic."[152] According to Bartlett, Camus sees justice and rights claims as originating in caring and implying a convergence in moral and political communities. Camus's rebellion is "an action that simultaneously rejects oppression and injustice and affirms human dignity. It is a claim for justice based not in

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[146] Held, *supra* note 143.
[147] Annette C. Baier, *What Do Women Want in a Moral Theory?*, 19 NOÛS 53 (1985).
[148] EXPLORATIONS IN FEMINIST ETHICS: THEORY AND PRACTICE 84 (Eve Browning & Susan Margaret Coultrap-McQuin eds., A Midland book, MB 697, Indiana University Press 1992).
[149] *Id.*
[150] Abraham John A. Limpin, *Contemporary Moral Problems - A Book Review*, SCRIBD.
[151] Elizabeth Ann Bartlett, *Beyond Either/Or: Justice and Care in the Ethics of Albert Camus*, *in* EXPLORATIONS IN FEMINIST ETHICS: THEORY AND PRACTICE 82 (Indiana University Press 1992).
[152] *Id.* at 84.

resentment of the privileges one doesn't have, but rather in the affirmation of who one is."[153] While Locke, Kant, and many others arrive at universal principles of justice through the application of impartial reason, Camus's rebellion ethic sees the origin of justice in care. Long after Kant, Rawls invoked the "veil of ignorance" as a device to ensure that our interests, passions, and caring do not interfere with our ability to perceive and derive principles of fairness. Camus argues, to the contrary, that we demand justice and derive its incumbent rights claims precisely because we care. Justice and rights originate from passionate and compassionate concern for both ourselves and others. The demand for justice arises from affirming and caring about one's own dignity as well from compassionately witnessing the oppression of others. Compassion, not a dispassionate calculation of rights, is thus, to Camus, the basis for recognizing human dignity and for demanding justice and action.

HUMANITARIAN CONTEXT OF THE LEAD POISONING EMERGENCY RESPONSE IN ZAMFARA

" . . . I've a very different idea of love. And until my dying day I shall refuse to love a scheme of things in which children are put up to torture." – Albert Camus[154]

While ethics of care or principles of justice could perhaps rekindle the fire of Dunantist humanitarianism and lay a broader foundation for action, they are each inadequate in themselves to resolve the moral questions that arise from humanitarian tragedies such as Zamfara. The crisis in Northern Nigeria presented moral questions on several dimensions – medical, environmental, global political economy, among others – that were intricately interwoven. What was clear in May 2010 was that children were dying and something had to

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[153] *Id.*
[154] ALBERT CAMUS, THE PLAGUE. 4.3.50–53 (*in* /z-wcorg/, Time Inc. 1962).

be done. At each stage of the response there were moral choices and decisions that had to be made.

Traditional humanitarian response has been toward natural disasters, the aftermath of armed conflict, epidemics, and droughts. Most natural disasters such as hurricanes, earthquakes, or tsunamis, are largely beyond human control. However, Zamfara's deadly calamity was caused by poor people trying to eke out a meager livelihood. It could have been avoided. Behind local extractive economic activity were powerful global economic forces that were unaware of and likely indifferent to the afflictions wreaked on the impoverished communities. The rising global demand for gold, the relative low investment required for extraction, illiteracy, and poverty precipitated one of the world's most iconic environmental public health disasters. Clearly, the humanitarian response in Northern Nigeria was non-traditional.[155] It required more than technical skills and supplies. It called for strategic alliances across disciplines and institutions and partners.[156] A non-traditional response of this nature and magnitude presents unique moral questions.[157]

The Deadly Confluence of Culture, Poverty, Global Political Economy, and Geology

Zamfara state, located in northwestern Nigeria, is mostly occupied by the Hausa and Fulani tribes.[158] The Hausa are found in Northern Nigeria in large numbers but are also in

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[155] Philippe Calain, *What Is the Relationship of Medical Humanitarian Organisations with Mining and Other Extractive Industries?*, 9 PLOS MED 3 (2012).
[156] Calain, *supra* note 61, at 3–5.
[157] *Id.* at 6–9.
[158] UGO M. AMORETTI & NANCY GINA BERMEO, FEDERALISM AND TERRITORIAL CLEAVAGES 337 (JHU Press 2004).

smaller numbers in other parts of sub-Saharan Africa.[159] Most of the Hausa people in Northern Nigeria practice Islam. Their culture reflects strict interpretations of Islamic beliefs. Islam was introduced in Northern Nigeria Hausaland in the 1300s through traders and clerics with Islamization becoming widespread by the 1800s.[160] Zamfara has a population of about three million people, most of whom are subsistent farmers or nomadic pastoralists.[161] Agricultural production in Zamfara, which falls under the Sudano-Sahelian ecology zone, has been adversely impacted by erratic rainfall patterns that have been attributed to global climate change.[162] In the recent past, Zamfara was ranked one of the states in Nigeria with the highest unemployment rates.[163] The gold rush following the global economic meltdown of the last decade was a welcome relief to many communities in Zamfara.[164]

Rural Hausa villages are organized via a multifarious social-economic stratification based on strong family ties, occupation, wealth, birth, and patron-client ties.[165] Gender roles are determined by the existing patriarchal system. The fundamental unit of Hausa society is the household compound (gida), which is headed by the senior male owner of the compound

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[159] J.C. Moughtin, *The Traditional Settlements of the Hausa People*, 35 TOWN PLANNING REVIEW 21, 21–23 (1964).
[160] William FS Miles, *Shari'a as De-Africanization: Evidence from Hausaland*, 50 AFRICA TODAY 51, 52–54 (2003).
[161] Nigeria National Bureau of Statistics, *Zamfara State Information*, *available at* http://www.nigerianstat.gov.ng/information/details/Zamfara.
[162] G.G. Jidauna et al., *The Effect of Climate Change on Agricultural Activities in Selected Settlements in the Sudano-Sahelian Region of Nigeria*, 4 ARCHIVES OF APPLIED SCIENCE RESEARCH 703, 707–9 (2012).
[163] Leadership Editors, *Statistics: Bauchi, Zamfara, Niger Top Jobless List*, Text, LEADERSHIP NEWSPAPER NG (Aug. 12, 2012), *available at* http://leadership.ng/nga/articles/32295/2012/08/12/statistics_bauchi_zamfara_niger_top_jobless_list.html.
[164] Heather Murdock, *Villagers in Nigeria strike gold*, GLOBAL POST (Nov. 30, 2012), *available at* http://www.globalpost.com/dispatch/news/regions/africa/nigeria/121120/artisan-independent-gold-mining-nigeria-corporations-gold-rush.
[165] FRANK A. SALAMONE, THE HAUSA OF NIGERIA 2 (University Press of America 2009).

(maigida).[166] Often the maigida is aided by his adult sons that are not yet wealthy enough to form their own compounds. Together they engage in farming in a hierarchically organized family farming system (Gandu).[167] In addition to farming, many households rear cattle, goats and sheep, albeit in small numbers. Occupational specialties such as blacksmithing, woodcarving, masonry, and carpentry are sometimes pursued on an individual basis.

The Muslim Hausa wife in the Zamfara villages is required to live in seclusion while providing labor for preparation of food, child care, and general domestic chores under an Islamic-based seclusion system called kulle or purdah in Arabic.[168] Because women are expected to be wives and mothers and to remain secluded within the compounds of their husbands, little value is placed on formal western education. This is especially true among rural populations. Separation from the outside world is most important while a married woman has reproductive potential. Respectability requires that female reproductive potential be under appropriate male control. After menopause, control of reproductive potential is no longer important and women are allowed much greater freedom. Some become active in the wider economy. Hence it is not unusual to see grandmothers in market places. Relaxed forms of purdah were first introduced in Northern Nigeria begun during the early years of Islamization.[169] Purdah did not become a predominant practice until the end of the Second

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[166] ROBERT MCC NETTING ET AL., HOUSEHOLDS: COMPARATIVE AND HISTORICAL STUDIES OF THE DOMESTIC GROUP 139–40 (University of California Press 1984).
[167] *Id.* at 140.
[168] ISLAMIC CRIMINAL LAW IN NORTHERN NIGERIA POLITICS, RELIGION, JUDICIAL PRACTICE. 59 (Amsterdam University Press 2010).
[169] Yakubu Zakaria, *Entrepreneurs at Home: Secluded Muslim Women and Hidden Economic Activities in Northern Nigeria*, 10 NORDIC JOURNAL OF AFRICAN STUDIES 107 (2001).

World War.[170] The Hausa people of Northern Nigeria are among the very few Islamic African populations where seclusion of adult females is strictly practiced as a cultural norm.[171]

As a general rule, rural Hausa married women of childbearing potential do not work outside the residential compound.[172] Husbands are expected to provide adequate food, either from their family farms or by purchase from local markets. In addition to agricultural cash crop production, the village Hausa men in Zamfara engage in contract labor, trade in fabrics, kola nuts, or other general items of trade. Married women spend long hours preparing food, taking care of children, and managing the household. Once their obligations to the household are met, women are free to pursue personal economic activities. The most common activities are cottage industry production of food for sale, including homemade cakes, home-packaged spices, porridge, etc.[173] Food, snacks, and other items produced by women at home are hawked by children who go from compound to compound, walk the village streets, or sit in central locations where other hawkers congregate.[174] By some estimates, the secluded women of Northern Nigeria contribute up to 50 percent of all household subsistence.[175] The onset of artisanal mining in the villages of Zamfara provided an opportunity for sequestered women to participate in the lucrative gold processing activities. Wives were recruited by their husbands to process ore within the compounds.[176] Mothers often processed ore with the same utensils

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[170] ISLAMIC CRIMINAL LAW IN NORTHERN NIGERIA POLITICS, RELIGION, JUDICIAL PRACTICE., *supra* note 168, at 58.
[171] Zakaria, *supra* note 169, at 110.
[172] Annita Tipilda et al., *Engaging with Cultural Practices in Ways that Benefit Women in Northern Nigeria*, 18 DEVELOPMENT IN PRACTICE 551, 552 (2008).
[173] Zakaria, *supra* note 169, at 117–18.
[174] Elsbeth Robson, *Children at Work in Rural Northern Nigeria: Patterns of Age, Space and Gender*, 20 JOURNAL OF RURAL STUDIES 193, 205 (2004).
[175] Zakaria, *supra* note 169, at 118.
[176] Tirima et al., *supra* note 12.

they used to prepare food for consumption and sale.[177] The processing of lead-rich gold ores within the residential compounds became a significant source of contamination in the villages.[178]

Hausa children in rural Northern Nigeria are expected to make significant economic contributions to their societies.[179] Elsabeth Robson, in a study on children's economic contribution in Hausaland, notes that children under 16 years and unmarried support secluded married women through hawking, running errands to purchase household goods at local markets, and, within the compounds, food preparation, general household chores, child care, and so forth.[180] Many young girls (and less often boys) travel for miles to hawk food in mineral ore processing areas outside the Zamfara villages.[181] This seemingly innocuous economic activity has inadvertently provided a significant source of lead exposure for these young girls and their families. The ore processing areas use a dry milling process that generates a good deal of dust that settles on the food. Those foods that the girls do not sell by the end of the day are brought back to the village compounds for consumption by families, thus exposing entire families to lead poisoning. In addition, the young hawkers bring contamination home on their clothes.[182]

Boys and young men in rural Hausa villages contribute a significant amount of labor on the family farms. Girls work on the farms as well, but generally only during times of high

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[177] Geoffrey S. Plumlee et al., *Linking Geological and Health Sciences to Assess Childhood Lead Poisoning from Artisanal Gold Mining in Nigeria*, 121 ENVIRONMENTAL HEALTH PERSPECTIVES 744, 6,17 (2013).
[178] Dooyema et al., *supra* note 4, at 603.
[179] Robson, *supra* note 174, at 193.
[180] *Id.*
[181] Simba Tirima et al., The Role of Dietary and Para-Occupational Exposures among Children during the 2010-2013 Lead Poisoning Epidemic in Zamfara, Nigeria 2014.
[182] *Id.*

labor needs, e.g., for planting, harvesting, and thrashing.[183] Robson emphasizes the wide range of work engaged in by rural Hausa children in farm production, households, and markets. She describes them as "competent agents" who contribute independently and alongside adults to the overall socioeconomic structure of the society.[184] During the period of artisanal mining, boys and young men were expected by their households to participate in the gold mining activities. This was not seen as unusual in the eyes of their communities, though it was viewed unfavorably by the international community.[185]

At the center of all production and social organization in the Hausa village is the family compound (gida).[186] The gidas are usually constructed with adobe bricks and plasters.[187] They have high walls and are entered only through a small entry area (zaure) that opens onto the street.[188] The zaure is the first port of call into the compound where the household head (maigida) greets visitors.[189] The rules of purdah that forbid casual interactions between the sexes make the zaure an important gateway into the compound where unrelated visitors are screened.[190] Women and children who are not from the household may enter and

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[183] Robson, *supra* note 174, at 201.
[184] *Id.* at 193.
[185] Human Rights Watch, Nigeria: Child Lead Poisoning Crisis (Feb. 7, 2012), *available at* http://www.hrw.org/news/2012/02/07/nigeria-child-lead-poisoning-crisis.
[186] SALAMONE, *supra* note 165, at 108; MARY WREN BIVINS, TELLING STORIES, MAKING HISTORIES: WOMEN, WORDS, AND ISLAM IN NINETEENTH-CENTURY HAUSALAND AND THE SOKOTO CALIPHATE, at xi (Social history of Africa, Heinemann 2007).

[187] NURA. JIBO, TRADITIONAL HAUSA ARCHITECTURE IN NORTHERN NIGERIA: DESIGN AND BUILDING OF THE ROYAL PALACE, CITY WALLS AND GATES OF NORTHERN NIGERIA (LAP Lambert Academic Publishing 2011).
[188] Oluwagbemiga Paul Agboola & Modi Sule Zango, *DEVELOPMENT OF TRADITIONAL ARCHITECTURE IN NIGERIA: A CASE STUDY OF HAUSA HOUSE FORM* 68.
[189] Cordelia O. Osasona, *From Traditional Residential Architecture to the Vernacular: The Nigerian Experience*, ONLINE HTTP: WWW. MUDONLINE. ORG/AAT/2007_DOCUMENTS/AAT_OSASONA 17, 18 (2007).
[190] *Id.*

leave the compound freely. Men who are not from the household are strictly forbidden from entering the compound. Only on rare occasions would strangers be allowed to enter. During the lead remediation process, this strict rule had to be waived by the local traditional leaders and emirs in order for strangers to enter and cleanup the compounds.[191]

Today, in most Northern Nigerian states there exists, alongside the official state and local governments, an important parallel system of governance by 'traditional rulers'.[192] These are unelected individuals whose roots of authority go back to the pre-colonial era when regional kings ruled with absolute power across Northern Nigeria. For the most part, the regional kings were spiritual Islamic leaders or caliphs who ruled their caliphates with the aid of emirate councils.[193]

When Britain conquered Northern Nigeria it applied the "indirect rule" approach to colonial governance that it had tried in other parts of the world. Insofar as no threat was presented to colonial rule, the British left the traditional Nigerian institutions intact or even co-opted and used them to control and tax the local populations.[194] The Northern Nigerian emirates thus became useful to the British as an integral part of the colonial administration. Accordingly, many caliphates enjoyed enhanced power and authority during the colonial era even though the final authority vested in the colonial crown.[195] When Nigeria gained independence from Britain in 1960, it adopted a vestige of the former empire. However, over time the powers of the traditional leaders have eroded. The post-independence governments

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[191] Tirima et al., *supra* note 12.
[192] Jibrin Ibrahim, *The Politics of Religion in Nigeria: The Parameters of the 1987 Crisis in Kaduna State*, REVIEW OF AFRICAN POLITICAL ECONOMY 65, 318–22 (1989).
[193] *Id.* at 314–15.
[194] William F.S. Miles, *Partitioned Royalty: The Evolution of Hausa Chiefs in Nigeria and Niger*, 25 THE JOURNAL OF MODERN AFRICAN STUDIES 233, 238 (1987).
[195] *Id.*

have sought greater power and control over the northern populations.[196] In fact, successive post-colonial governments in Nigeria have tried to marginalize the traditional leadership from the political process. This has been largely unsuccessful, as the northern states such as Zamfara have demonstrated an obstinate adherence to the philosophy of leadership that existed in the pre-independence caliphate.[197] The hierarchical structure of traditional leadership in the core Hausa states remains strong and is supported by state appropriations.[198] When the lead poisoning epidemic broke out in March 2010, it was the traditional leaders lead by the emir of Zamfara, Attahiru Mohammed Ahmed, who intervened in the affected villages to ensure that all ore processing was halted.[199] Additionally, when the federal and state governments instituted an artisanal mining moratorium, it was the emirs who ensured that it was properly put into effect.[200]

While by law the traditional systems of government in Northern Nigeria have been separated from civil government and politics, they remain a de facto and bona fide source of political legitimacy. The roles of the traditional rulers today include settling disputes involving family, communal, and religious life. They are seen by their "subjects" as custodians of both religion and tradition. The wide respect and moral certainty that is placed in the values and traditional beliefs upheld by the emirs are powerful forces in Northern

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[196] *Id.* at 241–58.
[197] Isaac Terwase Sampson, *Religion and the Nigerian State: Situating the de Facto and de Jure Frontiers of State–Religion Relations and Its Implications for National Security*, 3 OX. J LAW RELIGION 311, 321 (2014).
[198] Sani-Gwarzo Nasir et al., *From Intense Rejection to Advocacy: How Muslim Clerics Were Engaged in a Polio Eradication Initiative in Northern Nigeria*, 11 PLOS MED e1001687 (2014).
[199] Tirima et al., *supra* note 12.
[200] Imam Imam, *Lead Disaster: Emirate Alerts on More Deaths*, THISDAY LIVE (Aug. 27, 2010), *available at* http://www.thisdaylive.com/articles/lead-disaster-emirate-alerts-on-more-deaths/80068/.

Nigeria. The state authorities see the emirates as useful institutions that resolve many disputes that would otherwise clog the judicial systems. In the lead contamination crisis, the traditional leadership played a key role in facilitating the remediation. They continue to play a vital part in sustaining the remedy.

The long term sustainability of the environmental remedy implemented in Zamfara depends upon the commitment of the local communities, families, and individuals to adhere to safer mining practices aimed at curtailing the pathways of exposure to lead. This is quite difficult to achieve in a context where poverty prevails and artisanal mining is not regulated. Nigeria's scale mining sector is poorly developed and has been largely neglected since the discovery of oil in the late 1950s. The majority of gold mining in the country is artisanal and operates outside current laws and regulations. Although there are federal and state laws that govern the formal mining of surface and subsurface minerals in Nigeria, there is a lack of workable legal frameworks for transforming artisanal gold mining from an informal to a formal activity. It is quite challenging to develop and implement safer mining programs in a context where most mining is done by iterant individuals.

Toward an Ethical Framework for Environmental Public Health Disaster Response: Features of Environmental Humanitarianism

TerraGraphics, a for profit environmental engineering firm with limited experience operating in international medical humanitarian settings, found itself in the remote villages of Northern Nigeria because it was invited by CDC as part of an investigative team. CDC, a bilateral government agency, had been invited by the Nigerian government to help in assessing the nature and extent of the lead outbreak. The Nigerian authorities sought help

from CDC because they realized that that they did not have the capacity to characterize and respond to a disaster of this nature. Once the outbreak was sufficiently characterized, CDCs work was done and MSF, the international medical humanitarian organization with years of experience in complex humanitarian settings, offered to provide treatment. Yet it further became clear that returning treated patients to contaminated homes would render the treatment ineffective. Clearly, TerraGraphics personnel could not turn their backs on the dying children and poisoned communities. They knew what needed to be done. Years of experience remediating the Bunker Hill Superfund Site (BHSS) in the United States had given TG the technical wherewithal to address the Zamfara situation. Their personnel elected to stay and help. MSF's presence in Zamfara made it logistically possible for TerraGraphics (and its NGO successor, TIFO) to assume the humanitarian role of remaining in Zamfara to coordinate and assist in the remedial activities.

The Zamfara emergency response provides much fodder for ethical reflection on our obligation to respond to environmental public health disasters of this nature. As the environmental cleanup and overall response unfolded further ethical considerations emerged. Addressing these considerations cannot be reduced to answers grounded solely in technical expertise. For the questions are fundamentally ethical in nature and give call for development of a framework that could guide the traversing of other such environmentally-induced humanitarian crises.

Though tentative and provisional, we propose such a framework with the hope it will stimulate reflection and discussion. We know it will not fully satisfy, for we shun any attempt to articulate necessary and sufficient conditions for an environmental humanitarian response.

Instead, we offer only several characteristics or features that give rise to an imperative to act for humanitarian reasons in the face of environmental disasters.

Before identifying these features we note briefly why neither care ethics nor principles of justice can provide workable guidance, theoretical and practical, for understanding that an imperative to engage in an environmental response is mandated on humanitarian grounds. Justice is inapposite because it does not offer the relevant ethical impulse for humanitarian action. The concept of justice fundamentally addresses how "we measure our mistreatment of one another."[201] Accordingly, justice calls upon us to identify both the perpetrators of injustice as well as the victims. And it places substantial weight on crafting rectificatory responses to injustice that work to right the scales of justice as to both victim and perpetrator. We agree with Camus and others, like David Hume, that justice originates in compassion or a shared moral sentiment grounded in sympathy toward others.[202] In that respect it aligns with humanitarianism. Yet the sentiments of justice are those of "approbation and outrage, admiration and disgust" directed toward the agents of mistreatment.[203] Though these sentiments originate in compassion toward those suffering injustice, they direct our focus and action toward the agents of injustice in the form of seeking recompense or rectification. That is not what is demanded by our moral sentiments in situations like Zamfara. There, the call is for help and aid without concern for placing blame, identifying wrongdoers, or seeking recompense. Hence, the bilateral rectificatory concerns of justice are largely beside-the-point when our moral sentiments call for humanitarian action.

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[201] Douglas Lind, *The Execution of Ah Cho: Jack London's Footnote to Justice Theory*, 37 AUSTRALIAN JOURNAL OF LEGAL PHILOSOPHY 99, 128 (2012).
[202] See, e.g., DAVID HUME, AN ENQUIRY CONCERNING THE PRINCIPLES OF MORALS 20-34 (Hackett 1988) (1751).
[203] Lind, *supra* note 204, at 128.

Likewise, ethics of care cannot provide a theoretical basis for recognizing a moral imperative to act in environmental response to a Zamfara-like humanitarian disaster. This is for two reasons. First, ethics of care build off relationships. And second, they suggest that the strength of care called for from the standpoint of morality is correlated with the closeness of the moral agent to those to whom care is extended. This places a sharp wedge between ethics of care and humanitarian action. For as the Dunantist principles emphasize, humanitarianism requires impartial aid given to distant others without concern for any preexisting relationships. Indeed, the paradigm of humanitarian action involves extending aid to those toward whom there is no relationship. At the very least, any question of familial, communal, or other relationship as a prerequisite to the giving of assistance is antithetical to humanitarianism. Hence, ethics of care are fundamentally discordant with humanitarian action.

The framework for environmental humanitarianism that we wish to propose is, once again, merely tentative and provisional. It is tied to no single ethical tradition, though it draws features from several. We suggest that there are certain characteristic features that guide deliberation and provide a basis for finding an imperative obligation to commit to a humanitarian environmental response. Such a response is called for when (1) overpowering sentiments of human sympathy or compassion suggest (2) that only humanitarian action can accord to persons suffering from an environmental disaster the respect they are due as beings with inherent worth and dignity, (3) that the action contemplated will serve overall human well-being (4) in a manner consistent with the Dunantist humanitarian principles, and (5) that the action can be performed free of paternalist interference with any cultural beliefs, traditions, or institutions causally disconnected from the environmental disaster.

The first feature of environmental humanitarianism is human sympathy. Here we stand in consort with Camus and his rebellion ethic. Yet more significantly, we lean upon the august tradition of eighteenth century British moral sense philosophy, as exemplified in the works of Francis Hutcheson,[204] David Hume,[205] and Adam Smith.[206] To these philosophers, the impetus to right conduct and to the value we place on the social virtues comes initially not from reason but sentiment. Their conception of that moral sentiment – literally a "moral sense" – was of a powerful feeling of compassion or benevolence toward others. It is a sentiment, made universal in our species by nature, through which we take a genuine interest in others' well-being. A century later John Ruskin would argue that this high conception of moral sympathy provides the grounding for all the social virtues, i.e., that "the imaginative understanding of the natures of others, and the power of putting ourselves in their place, is the faculty on which virtue depends."[207] To Norman Fiering, it is this sentiment of "irresistible compassion" that provides the force behind humanitarianism.[208] Humans are naturally inclined to relieve suffering.[209] It is easy to understand how this universal sentiment, this irresistible compassion toward the well-being of others, provides a ready basis for understanding the decision by the TerraGraphics personnel in Zamfara to initiate an

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[204] See, e.g., FRANCIS HUTCHESON, AN ESSAY ON THE NATURE AND CONDUCT OF THE PASSIONS AND AFFECTIONS, WITH ILLUSTRATIONS ON THE MORAL SENSE (Liberty Fund 2002) (1728, 1742); FRANCIS HUTCHESON, AN INQUIRY CONCERNING THE ORIGINAL OF OUR IDEAS OF VIRTUE OR MORAL GOOD, in PHILOSOPHICAL WRITINGS (R.S. Downie ed., J.M. Dent 1994) (4th ed. 1738).
[205] See HUME, *supra* note 202.
[206] E.g., ADAM SMITH, A THEORY OF THE MORAL SENTIMENTS (1759).
[207] JOHN RUSKIN, FORS CLAVIGERA (1873).
[208] Norman S. Fiering, *Irresistible Compassion: An Aspect of Eighteenth-Century Sympathy and Humanitarianism*, 37 JOURNAL OF THE HISTORY OF IDEAS 195, 196 (1976).
[209] *Id.*

environmental response. To have walked away from scores of children in distress would have been an inhuman response, one at odds with our basic sense of moral good.

The second feature of environmental humanitarianism attributes the imperative to act on a recognition that it is only through humanitarian action that persons suffering from an environmental disaster can be accorded the respect they deserve as beings with inherent worth and dignity. This could be thought of as the Kantian feature. For it was Kant, through the second formulation of his categorical imperative, who first posited the concept of universal inherent human worth, i.e., that a necessary condition for right conduct is that all people be treated with dignity and as ends-in-themselves. Simply put, environmental humanitarianism recognizes that the value of humans is above all price. Regardless of role or station, familial relation or distant other, each person is entitled to moral respect. Yet a fortiori, this basic right of human respect is an entitlement accompanied by a concurrent moral obligation to act respectfully toward others. When those others are found in poisoned communities like those of Zamfara, the basic human right to be treated with dignity and respect converges with the obligation of respectful action to create the imperative of engaging in environmental, humanitarian response.

Third, any action contemplated by this ethic must be calculated to serve overall human well-being. This feature follows necessarily from the sentiment of moral compassion. Hutcheson, in providing the first systematic account of the moral sense, posited that the "*universal foundation* of this *moral sense* … [is] *benevolence*, … an[] action['s] … *usefulness* to the *public*."[210] Indeed, he maintained that the moral sense supports the prescription "that *that action* is *best*, which procures the *greatest happiness* for the *greatest numbers*, and *that*

[210] HUTCHESON, AN INQUIRY CONCERNING THE ORIGINAL OF OUR IDEAS OF VIRTUE OR MORAL GOOD, *supra* note 204, at 95.

worst, which, in *like manner*, occasions *misery*."[211] This utilitarian feature imposes a consequentialist justification on humanitarian action. It demands that any environmental response undertaken on humanitarian grounds be assessed, from the outset, in part on the basis of its reasonably foreseeable outcomes. In the Zamfara response, the expected outcome and that produced was positive on several accounts. Mortality and morbidity among young children were significantly reduced. Blood lead levels, a key indicator of a successful intervention, declined over the course of the response. Environmental data suggest that the overall exposure to lead for the affected was significantly curtailed. Technical capacity skills were introduced to the local populations in order to deal with future potential problems. By all accounts, these are positive outcomes. The Zamfara response provides a model of successful environmental humanitarianism. Nevertheless, it is critical to be aware of possible unintended, negative consequences of even this example of humanitarian assistance. For instance, did the response in Zamfara create apathy or lethargy on the part of the Nigerian statutory authorities that could reduce their incentive to act in the future? This is an important question because the consequence of humanitarian effort should not be to give excuse to statutory authorities to disavow their obligations to act. Recognizing such potential for unintended harm underscores the critical need to evaluate outcomes and develop standards to minimize the negative impacts of assistance. In most humanitarian emergency situations, critical need exceeds the available resources. Consequently, operational dilemmas emerge in allocating scarce resources and finite effort to needs. What mechanism should be used to determine where to apply scarce resources or where to triage activity? Attentiveness to this utilitarian feature can aid decision-making regarding the selection and prioritization of activity.

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[211] *Id*. at 90.

Fourth, the Dunantist principles of humanity, neutrality, impartiality, and independence contribute another necessary feature to the environmental humanitarianism framework. These principles are foundational in setting forth standards for humanitarian conduct and remain a vital compass for organizations that provide relief aid. They facilitate access to populations, help identify key areas of suffering, allow impartial protection of human rights, and assist actors in maintaining suitable distance from non-neutral actors and restrictive, rigid templates for action. The efficacy of these Dunantist principles, however, depends on the specific disaster context and a pragmatic appreciation of the complexities involved. In contexts such as the Zamfara lead poisoning epidemic, a tension between humanitarian assistance ideologies could emerge. This tension can be presented as a contrast between two ideologies: (1) the strict Dunantist approach to humanitarian assistance, with the goal of short-term relief geared toward saving lives and mitigating suffering, and (2) the integrated approach to aid, where longer-term activities of recovery are interlocked with social and economic development objectives. These tensions are well exemplified in the multidisciplinary response in Zamfara. While the Zamfara context had the classic components of a humanitarian medical response, i.e., clinical care for the acutely affected and broader public health interventions and advocacy for the larger community, it also included the critical requirements of environmental remediation and safer mining practices, on which attaining sustainable blood lead level reduction was dependent.[212] Medical treatment, environmental remediation, and adoption of safer mining programs have been identified as the three pillars

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[212] Natalie Thurtle et al., *Description of 3,180 Courses of Chelation with Dimercaptosuccinic Acid in Children ≤5 Y with Severe Lead Poisoning in Zamfara, Northern Nigeria: A Retrospective Analysis of Programme Data*, 11 PLOS MEDICINE e1001739, 10 (Bruce P. Lanphear ed., 2014).

of the successful intervention in Zamfara.[213] However, development and implementation of remediation and safer mining programs goes beyond the strict Dunantist principles of autonomous and independent action. Operating in this relatively new terrain for humanitarian organizations – i.e., outside the traditional humanitarian response to armed conflict, epidemics, and natural disasters – requires a deeper examination of which types of compromises and alliances with key stakeholders are acceptable in order to implement a successful intervention. Realizing a successful environmental remediation project in a context like Zamfara requires adaptation of technologies to fit the local socio-economic and cultural context, involving local communities in project development and implementation, and broader institutional collaboration to help sustain the remedy. This level of involvement among key stakeholders requires a pragmatic moderation of tensions between differing humanitarian assistance approaches that could otherwise undermine such collaboration.

The final feature of the ethic advanced here is that any environmental response undertaken on humanitarian grounds must be performed without paternalist encroachment on any traditions, cultural beliefs, or institutions (familial, religious, social, or political) that are causally disconnected from the environmental disaster. Most humanitarian disasters present settings where the affected need immediate help to save lives and alleviate horrendous suffering. It can be quite challenging for humanitarian actors to be fully accountable and inclusive in such circumstances. There is a tendency to assume a paternalistic posture. According to Michael Barnet ". . . paternalism is a latent or manifest feature of all relationships of compassion. Accordingly, to end paternalism in our lifetime would mean to

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[213] MSF, *Time is Running Out: Six-Month Progress Report on the May 2012 International Conference on Lead Poisoning*, Progress Report (Médecins Sans Frontières (MSF)), Nov. 2012.

cleanse humanity of these other highly desirable human traits."[214] Barnet may be correct that action in aid of others driven by compassion is naturally interconnected with attitudes of paternalism. However, it is critical to check the impulse of humanitarian paternalism, if such there is, with respect for the agency and moral autonomy of those receiving help. This is a limiting principle which dovetails the Kantian feature of respect for all people as ends-in-themselves. The moral obligation to provide humanitarian aid must be informed by tolerance, respect for diversity, and acceptance of all beneficiaries' moral standing as autonomous individuals. Yet there is also a consequential side to this limiting principle. For it is important to recognize that paternalism that is insensitive to culture may lead to project failure. Cultural differences between humanitarian actors and beneficiaries can lead to disruption of humanitarian operations.[215] An environmental response such as in Zamfara required working very closely among multiple stakeholders, including local communities, traditional leaders, local, state, and federal authorities. Not only must cleanup approaches be adapted technically to fit the local context, they must also be adapted in terms of human and social interaction.

CONCLUSION

The Zamfara lead poisoning outbreak is not an isolated incident. Human exposure to toxic chemicals is a pervasive fact of modern life. On a global scale, the byproducts of consumption have disproportionately impacted some of the poorest regions of the world, often severely affecting long-term health and other life prospects of vulnerable populations. The

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[214] MICHAEL N. BARNETT, THE INTERNATIONAL HUMANITARIAN ORDER 213 (Security and governance series, Routledge 2010).
[215] Juan Rodon et al., *Managing Cultural Conflicts for Effective Humanitarian Aid*, 139 INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS 366, 365 (Compassionate Operations, 2012).

world's poorest and most vulnerable regions are recipients of hazardous waste, hazardous products, and preferred sites for dangerous economic activities. Exposure to toxic chemicals is an important contributor to chronic disease in many regions of the world where people who live in poverty struggle on a daily basis to eke out livelihoods in order to gain basic necessities of life.

Acute cases of exposures leading to catastrophic environmental public health disasters are recorded in recent history. However, rarely have those catastrophic events been viewed through the lenses of traditional Dunantist humanitarian response. The Zamfara lead poisoning epidemic however was uniquely placed within the Dunantist humanitarian space through at least three unique circumstances. First, the outbreak was discovered by MSF (an archetypal Dunantist medical humanitarian organization). By MSF standards, the scale of the outbreak clearly exemplified the features of a widespread humanitarian disaster. Secondly, the nature and scale of the disaster totally eclipsed the capacity of the statutory authorities in Nigeria. Thirdly, this disaster was located in an impoverished and a very remote part of the world that is very difficult to access due to poor infrastructure.

The Zamfara response became multisectoral/multidisciplinary in that it included a Dunantist humanitarian organization, international bilateral agencies, a private US environmental engineering firm, an international antipollution NGO, national and local governments, traditional leadership and local communities, local and National NGOs, and several multilateral international organizations. Operating in this relatively new terrain – outside the traditional humanitarian response to armed conflict, infectious disease epidemics, and natural disasters – for humanitarian and other organizations raised obligatory and operational ethical concerns deserving of thorough examination. It is clear that responding to

this kind of emergency cannot be reduced to the development of technical expertise alone. Perhaps an environmental humanitarian ethical framework, as proposed by this article, can help structure discussions at all levels on the way forward in responding to this new wave of disasters. Environmental humanitarianism is a general ethical framework comprising features derived not from a single moral philosophy, but is fashioned from a range of normative considerations and precepts. The ethical framework as conceived in this article is not a complete ethic whatsoever. It is merely a beginning step toward setting an agenda for discussing a rather complex moral landscape.

In the end, we are advocating for a framework that fully embraces the idea that humans have duties to alleviate suffering when it occurs. Those duties to act are translated into action by a radical sympathy that draws on suffering the distant other as a frame of reference. It is a sympathy that causes us to recognize the social and biological unity of human community. There is also the recognition of the need to go beyond the minimal conceptions of humanitarianism – responding only to extreme or emergency cases – to committing to justice and to seeking transformation of global structures that precipitate suffering.

Chapter 5

Conclusion

The linkages between the environment, poverty, and public health are well documented. Environmental hazards have been shown to impact human health, either directly, by exposing people to harmful agents, or indirectly, by disrupting life sustaining ecosystems. The WHO claims that approximately one-fourth of all global disease, and more than one-third of the burden among children, can be attributed to modifiable environmental factors. WHO further estimates that approximately 24% of all global disease burden (healthy life years lost) and 23% of all deaths (premature mortality) can be traced to the environment, with the environmental burden of diseases being 15 times higher in developing countries than in developed countries, due to differences in exposure to environmental risks and access to health care.

Environmental pollution is a major source of health risk throughout the world, although risks are generally higher in developing countries where poverty, lack of investment in modern technology, and weak environmental regulation combine to cause high levels of pollution. Establishing causality between environmental pollution and health outcomes in poor and developing countries, however, can be difficult. For instance, predicting with certainty the causes and effects of environmental pollution on human health may require controlled experiments that compare people exposed to contaminants to those who are not. Not only are such investigations morally troublesome. Exposures may occur through a range of pathways and processes, and levels are often uncertain, or unknown, due to lack of

monitoring. Outcomes may go undetected from poor surveillance, faulty diagnoses, or variation in response among population groups. Latency in disease manifestation, the effects of cumulative and multi-pollutant exposures, and numerous environmental and socio-economic cofactors confound associations between pollution and public health.

In spite of the challenges associated with environmental public health disasters, the Zamfara lead poisoning has demonstrated that it is possible to develop and implement a workable response even in the remotest of regions. This Nigerian project would not have been possible without: i) careful adherence to sound scientific techniques and protocols for mitigating lead exposures through integrated remediation, treatment, and advocacy, ii) the experience gained from previous projects in adapting those techniques to local conditions in diverse cultural and geographic situations, iii) the logistics and security support provided by the experienced international organizations MSF, WHO, and CDC, and iv) the engagement and leadership provided by the Nigerian federal, state, local, and traditional governments, along with the members of the affected communities. This tragic incident and subsequent response demonstrate that, with sufficient political will and modest investment, even the world's most challenging environmental health crises can be addressed within the capabilities of the host countries.