Community Perceptions on Health Risks Associated With Toxic Chemical Pollutants in Kwekwe City, Zimbabwe: A Qualitative Study

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ABSTRACT: Globally, environmental pollution continues to be a significant public health problem, and according to the World Health Organisation, pollution-induced deaths account for 23% of deaths yearly, which could be prevented if people lived in healthier environments. Despite implementing multilateral agreements and international treaties such as the Bamako, Basel, Rotterdam, Minamata, and Stockholm conventions, the United Nations Sustainable Development Goals, and national laws, toxic pollutants remain a serious environmental and public health problem in low-income countries. In the specific context of Kwekwe City, an industrial and mining area in Zimbabwe, where environmental and pollution-induced health problems associated with industries have been widely reported, this study was conducted in close collaboration with the local community. The study aimed to assess community members' perceptions regarding health risks associated with potentially toxic elements and cyanide pollution in Kwekwe City. An explorative cross-sectional study was conducted with key stakeholders and industrial settlements' residents. Face-to-face interviews with key informants and focus group discussions with residents and workers were used to gather data. A thematic approach was utilised in data analysis. Study participants, who played a crucial role in the research process, perceived that industrial pollution principally linked to cyanide, mercury and chromium posed significant environmental and health risks. This participatory approach in risk perception assessment is critical in providing insight into the scope of the problem and formulating intervention strategies. However, given that qualitative study results lack generalisability and replicability, quantitative studies need to be undertaken to determine environmental levels of toxic chemical pollutants as a complementary and validative measure.

KEYWORDS: Cyanide, environmental pollution, heavy metal, potentially toxic elements, risk perception, sustainable development goals

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Introduction

According to the World Health Organisation (WHO), environmental pollution accounts for 23% of global deaths and 26% of deaths among children under 5, which could be prevented if people lived in healthier environments.[1] Potentially toxic elements (PTEs) have been identified as hazardous environmental pollutants of public health concern and are aetiologically linked to acute and chronic health conditions.[2] Most PTE-mediated high-burden diseases are prevalent in low-income countries, except cardiovascular diseases and cancer, which are much higher in developed countries.[1,3] Several studies identified PTEs as responsible for causing non-communicable diseases and significant threats to public health.[4-8] PTEs are micro or heavy metals (HMs) and metalloids that are harmful to humans and other organisms even at low concentrations, and these include but are not limited to arsenic, cadmium, cobalt, copper, chromium, lead, mercury and zinc. These elements cause cancer, reproductive problems, respiratory conditions, internal organ injuries, endocrine disruption, and mental health problems, among other conditions.[9-11]

Most traditional environmental epidemiology studies primarily focused on quantitatively determining potentially toxic pollutants' levels, distribution, pollution indices, statistical data analysis and health risk assessments, with little or no complementary voices from affected communities.[2,7,12] Including the citizenry's views in risk perception assessments is critical in policy formulation and implementation. According to Leuenberger et al., participatory health impact assessment fosters strategic interventions, includes marginalised population groups, and protects and promotes the health of local communities. Including community perspectives before and during project, implementation helps policymakers leverage economic opportunities while avoiding the pitfalls, thus bringing their communities closer to achieving good health and well-being goals by 2030 and beyond.[12] Studies on community health risk perceptions are essential in successfully implementing environmental and public health policies and interventions.[4,5]

Like elsewhere in low-income countries, Sub-Saharan African countries are more concerned about growing their economies through industrialisation, albeit at the expense of

the environment and public health.[3,5,13] In a study in Kenya, 80% of participants perceived pollution from a local factory as a high risk to them and argued that they should have been consulted on finding solutions to the environmental and health problems caused by the factory.[13] The residents conceded that while they benefited from the factory through employment, they perceived exposure to pollutants (82%) as the cause of heart, respiratory, and skin conditions in the area. Another study on Kamituga artisanal mining in DR Congo showed that the practice of gold amalgamation using mercury was a health risk to workers.[14] The authors reported health conditions (chronic pulmonary diseases, tuberculosis, insomnia, gastrointestinal disorders and headaches) of mine workers exposed to chemicals such as mercury, silica, arsenic, lead, and cyanide.[14] In another study in Kenya, people who worked and resided near industries were aware of the high risk of air pollutant exposure but were unwilling to abandon the site because of the economic benefits associated with the sources of pollution.[5] In a study on the health impacts of industrial mining on surrounding communities in Tanzania, Burkina Faso, and Mozambique, the perceived negative determinants included pollution.[12] Study participants perceived pollution from mining activities to have degraded the quality of the environment, caused chronic diseases and deaths, lowered the quality of life and reduced life expectancies in the communities. In low-income countries, cyanide is a very poisonous chemical commonly used in the extraction of gold. It is associated with brain damage, seizures and thyrotoxic and neuropathic conditions in humans.[2,15]

Qualitative studies on community risk assessment of pollutants are scanty compared to quantitative studies in Zimbabwe. In a study of artisanal and small-scale gold mining in Kadoma and Shurugwi, miners were exposed to mercury, cyanide, chemical dust and gases.[16] The study found that miners engaged in open amalgam burning and cyanide leaching from mercury-containing tailings. While the study did not explore the health conditions that affected the exposed miners, the level of health perceptions and awareness among them was low, and little to no safety guidelines were followed. More qualitative and quantitative peer-reviewed studies in Kwekwe City need to be conducted, and the few quantitative studies indicated the existence of health problems associated with toxic pollutants. A study of the biggest ferrochrome company in Zimbabwe with a smelter in Kwekwe City found elevated concentrations of copper (Cu), chromium (Cr), iron (Fe) and zinc (Zn) in particulate matter emission. The soil within a radius of 700 m from the smelter had high levels of Cr, whose hexavalent form ($cr+^{6}$) is a known human carcinogen.[17] Some workers' compounds and residential suburbs were located within a distance of 100 m from the smelter; this significantly exposed these people to smelter emissions. Kwekwe City's land-use activities, which include mining and mineral processing and heavy industrial manufacturing, are potentially major sources of PTE pollution. Artisanal miners in the area use large quantities of mercury (Hg) and cyanide (CN) to extract gold from the ore; there is little regard for proper disposal of these chemicals, which end up in the environment.[2] There have been several media and community reports on the death of fish, cattle, goats and human poisoning in the city, whose causation has been linked to environmental pollutants.

This cross-sectional qualitative study explored community health risk perceptions of PTEs and cyanide-mediated environmental pollution. While the results of quantitative studies are regarded as more trustworthy and informative in decision-making, this study addressed SDG 3 on improving health outcomes related to pollution problems through stakeholder involvement in research. This is critical in complementing and buttressing the quantitative studies and provides insight to policymakers and authorities on the need to address environmental and health problems.[12,14] The study also addressed SDG 11 (sustainable cities and communities) and air pollution control in urban limited public spaces. The study borrowed from the Basel, Rotterdam, Minamata and Stockholm Conventions, multilateral environmental agreements and international treaties that address hazardous waste and chemicals management.

Materials and Methods

Study area and description

Kwekwe City is situated in the Midlands Province of Zimbabwe and lies between 18° 92′ S and 29° 81′ E. The city's geology comprises relics of the Sebakwian group, such as rafts of serpentine, greenstone, ironstone and ultramafic rocks.[18] The study area selection was premised on its diverse industrial activities and associated potential environmental problems. As shown in Figure 1, mining, mineral processing, smelting and ancillary industrial activities are the mainstay of the local economy. The city experienced robust population growth spurred by extractive industries, from 88 000[19] in 2002 to 120 000 in 2022. The study participants were drawn from the city's heavy industrial and mining areas and nearby residential areas.

Study design

We conducted a qualitative exploratory study to assess community health risk perceptions associated with PTE and cyanide pollution at selected study sites in Kwekwe City. Data were gathered from participants through in-depth face-to-face interviews and focus group discussions (FGDs).

Participant recruitment and data collection

As gatekeepers in the community, local leaders assisted in recruiting FGD participants and setting dates and times for the group discussions. The FGD participants had different ethnic backgrounds, educational levels and employment statuses and

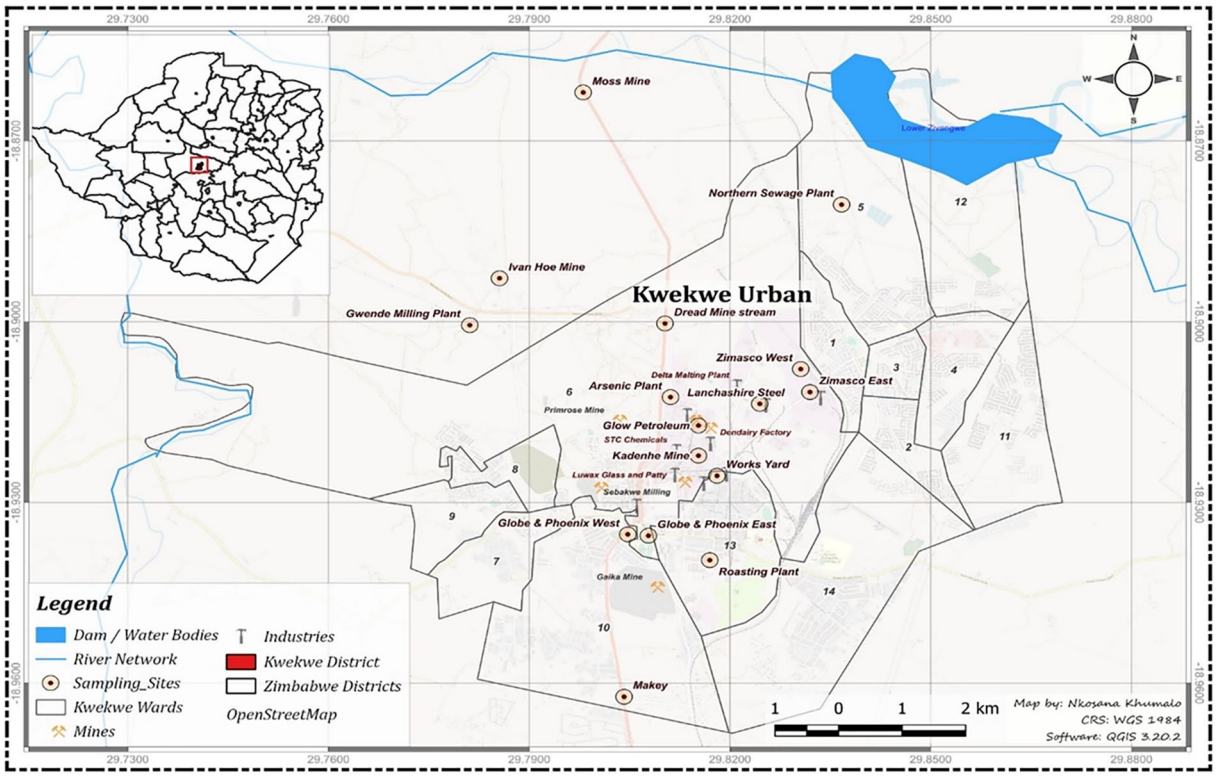

Figure 1. Location of study sites in Kwekwe City.

stayed in the community for at least 6 months. Most FGD participants were industrial workers, self-employed and unemployed residents of industrial settlements. Written informed consent was obtained from all research participants before the FGDs. The FGDs were conducted in 3 main languages spoken in the area: English, Ndebele and Shona. The first author and 2 research assistants conducted the FGDs using an unstructured FGD guide during working hours.

Participants were purposively selected, and only one participant from each household was selected to participate in the FGDs to minimise dominance and bias. This also helped ensure that more participants with diverse views took part and, more importantly, ensured that the exclusion criteria were followed. The purposive selection of participants ensured better matching of samples to the study's aims and objectives, which is critical in achieving the rigour and trustworthiness of the data and results. Five FGDs were conducted in 209 minutes with adult participants (n = 40) who resided. Each focus group comprised 6 to 9 participants of almost equal gender representation. The FGDs were conducted at sites near participants' residential areas. These included Roasting Plant (39 minutes), Globe and Phoenix Mine Hall (40 minutes), Old Mbizo Housing Office (49 minutes), Dread Mine (33 minutes) and Lancashire Steel (48 minutes). The number of FGDs was determined by data saturation. Data saturation occurred when it was realised that no new codes or ideas were being generated from the discussions in the fifth FGD, and the FGDs were consequently stopped.

Forty-one (41) health professionals, regulatory authorities, community leaders and policymakers were purposively chosen as key informants to participate in face-to-face interviews. Participants included medical doctors (4), nurses (10), environmental health practitioners (9), teachers (8), councillors (4), environmental regulatory officers (3) and local authority managers (3). These participants lived or worked in the study area and were presumed to understand environmental and health issues prevalent in the city.

An interview guide was used to collect data and meet study objectives. Unstructured interviews with key informants were conducted at workplaces or residences during the day and working hours. The interviews were conducted in private rooms, and prior appointments were made to minimise participant activity disruptions. The data collection process took 15 to 30 minutes for each participant. Interviews with participants continued until we deemed data saturation to have been reached; at that point, no new information emerged.[20,21] Data saturation was reached at Participant number 38. However, interviews continued to confirm data saturation and stopped at Participant 41. The data was collected between September 2023 and January 2024. Before recordings were made using an iPhone 12 digital voice recorder, permission was obtained from FGD and interview participants. The response rates for interviews and FGDs were 85% and 87%, respectively.

Persons who were terminally ill, drunk, juvenile, disinterested or obstinate were excluded from FGDs and face-to-face interviews. For both interviews and FGDs, participants were of

equal gender representation and were aged between 18 and 65. The authors chose the 18 to 65 age group, which understood the research and historical events and issues around the study topic better, as informed by a pretest of research tools conducted before the commencement of the study. The pretest showed that residents outside the 18 to 65 age group did not have a good awareness or perception of the city's past and current environmental events.

Data analysis

The collected data were transcribed verbatim in Microsoft Word and translated into English if in Shona or Ndebele. The English transcripts were then converted to PDF format and imported to R-Software (Version R-4.2.2) for coding and thematic analysis. The interrater method (code-recode strategy) was used for coding data. It involved leaving the data for some time and recoding it later, followed by comparing the 2 sets of coded data. Themes were generated from codes as features of participants' accounts, which characterised perceptions or experiences that the researcher deemed relevant to the research question.[20] One of the authors is an expert in qualitative research and was responsible for re-coding to validate generated codes and themes. The study's findings were presented thematically in themes and sub-themes.

Trustworthiness of the study

The trustworthiness of the research was ensured by observing and incorporating credibility, dependability and conformability guidelines in the study.[2,20,22] Research credibility was achieved through prolonged engagement, peer debriefing, negative analysis and member checking.[22] Using FGDs and interviews as data collection instruments contributed to research credibility and reliability. Additionally, subject matter experts (medical doctors, environmental health practitioners, environmental scientists and nurses) were involved in the study and method/data triangulation to ensure the credibility of the findings. The authors got ethical clearances from the University of Venda and the Medical Research Council of Zimbabwe, and experts and key stakeholders' participation was critical in ensuring research reliability.[2,20] Finally, conformability was achieved by submitting the manuscript to peer-reviewed journals to enable reviewers to scrutinise the data collection methods, data analysis techniques and data interpretation. Generalisations or transferability of qualitative studies to other areas or communities is always a challenge; however, the research process can be repeated, though not replicable, due to the differing perspectives, such as the realities of the participants' lived experiences.

Results

Characteristics of study participants

Eighty-one (81) participants took part in the study. Forty (40) key informants (22 women and 18 men) were recruited and participated in the FGD, while forty-one (41) participants (20 women and 21 men) participated in the interviews. According to Creswell and Creswell,[20] there are no hard and fast rules around how many people can participate in a qualitative study.[22] However, other researchers estimate that between 10 and 50 participants are sufficient. The sample size in qualitative studies can be determined by thematic saturation, a point at which new data does not contribute to the findings due to the repetition of themes and participant comments.[20-22] Four FGDs were conducted with 8 or 9 participants, and the Roasting Plant FGD had 6 after 2 male participants withdrew due to a family bereavement and had to be excused. All FGD and interview participants' ages ranged between 18 and 65 years. Ninety-eight percent of FGD and interview participants had primary or secondary education, and 18% were formally employed. The key participant characteristics are presented in Table 1.

Themes that arose from the data

The participants' narrations from interviews and FGDs formed 5 themes and 15 sub-themes, as shown in Table 2. The main themes included health conditions associated with potentially toxic elements and cyanide pollutants; drivers of potentially toxic elements and cyanide environmental pollution; factors associated with exposure to potentially toxic elements and cyanide pollution; challenges in environmental and health care management systems and strategies and interventions to solve identified problems. The findings were presented in sections according to the 5 thematic areas identified.

Health conditions associated with potentially toxic elements and cyanide pollutants. One of the main themes that arose from the findings was health conditions associated with potentially toxic elements and cyanide pollutants. Under this main theme, 3 sub-themes emerged, and these are described and explained as follows:

Prevalent non-communicable diseases. Participants cited several prevalent non-communicable diseases that were perceived to be associated with potentially toxic elements and CN. They cited cases of non-communicable diseases encountered in the community, such as cancer, cardiovascular, reproductive and mental disorders. The participants mentioned different types of cancers that they have witnessed in the community, such as skin, abdomen, thyroid, cervical, kidney, prostate, breast, lung and others.

Participants said:

> *"Prevalent non-communicable diseases include. . .. . .. cervical, breast, skin, and prostate cancer." (Participant 5, Individual Interview, female, 52 years).*

> *"Some of us do not understand how cancer manifests or what a person with the condition looks like. We lost one child who developed a wound that worsened until the child died, but we were unsure whether it was cancer." (Participant 4, FGD 1, female, 40 years).*

Table 1. Background characteristics of study participants.

CHARACTERISTICS	FGD, N (%)	INTERVIEW, N (%)
Gender		
Female	22 (55.0)	20 (48.8)
Male	18 (45.0)	21 (51.2)
Age		
18-28 y	9 (22.5)	9 (22.0)
29-39 y	12 (30.0)	14 (34.1)
40-65 y	19 (47.5)	18 (43.9)
Residential area/workplace		
Mbizo	9 (22.5)	5 (12.2)
Lancashire Steel	9 (22.5)	3 (7.3)
Roasting Plant	6 (15.0)	3 (7.3)
Globe and Phoenix Mine	8 (20.0)	3 (7.3)
Dread Mine	8 (20.0)	2 (4.9)
CBD	0.0	15 (36.6)
Amaveni	0.0	4 (9.8)
Industrial area	0.0	6 (14.6)
Residential/working duration in the area		
0.5-10 y	6 (15.0)	10 (24.4)
11-20 y	21 (52.5)	17 (41.5)
21+ y	13 (32.5)	14 (34.1)
Educational level		
None	2 (5.0)	0.0
Primary	7 (17.5)	3 (7.3)
Secondary or higher	31 (77.5)	38 (92.7)
Occupational status		
Unemployed	12 (30.0)	8 (19.5)
Employee	19 (47.5)	17 (41.5)
Self-employed	9 (22.5)	16 (39.0)
	n = 40	n = 41

"I had my uncle, who used to work for a ferro-chrome smelter, who died from cancer which affected his leg." (Participant 8, FGD 1, female, 49 years).

Several FGD and individual interview participants mentioned the respiratory conditions they perceived to be associated with toxic industrial pollutants. While most residents and workers in industrial settlements could not mention conditions by name, key informants such as nurses, environmental health practitioners and doctors said that conditions such as silicosis,

Table 2. Main and sub-themes of the study.

MAIN THEMES	SUB-THEMES
• Health conditions associated with potentially toxic elements and cyanide pollutants	• Prevalent chronic diseases • Human and animal deaths from unknown causes • Unintentional chemical poisoning
• Drivers of potentially toxic elements and cyanide environmental pollution	• Industrial emissions and discharges into the environment • Failed environmental management systems • Illegal and unregulated mining activities
• Factors associated with exposure to potentially toxic elements and cyanide pollution	• Living near or working in polluted environments • Rearing animals and growing crops on contaminated land • Use of contaminated surface water for household purposes • Consumption of fish from unreliable sources
• Challenges in environmental and health care management systems	• Inadequate law and policy enforcement • Poorly equipped healthcare facilities and lack of resources • Lack of knowledge and awareness about non-communicable diseases
• Strategies and interventions proposed by research Participants	• Improved environmental management • Improved healthcare facilities and measures

lung disease, chest pains, asbestosis, asthma, and difficulty breathing were common in the city. Some participants perceived the inhalation of industrial emissions to have caused these health conditions.

Participants said:

"I am one of those who used to work at a nearby mine handling chemicals. I was fortunate that my condition was diagnosed early during a council-clinic outreach screening program. I was a buyer of mine chemicals, such as cyanide, mercury, caustic soda, and nitric acid, and was exposed to these chemicals for seven years. The office that I used to operate from the stored cement as well, and I fell sick. My chest was painful, and my lungs were damaged, so I resigned from work due to these health problems." (Participant 2, FGD 4, male, 64 years)

"Yes, I have seen people who have developed silicosis and silico-TB due to breathing mine dust, and they had developed lung and breathing problems. Most of these people died from this disease since they were diagnosed late and the disease was discovered at advanced stages. . ." (Participant 35, Individual Interview, female, 42 years)

Other non-communicable diseases that participants frequently mentioned included cardiovascular, mental health, skin, reproductive conditions, diabetes, allergies, anaemia and gastroenteritis. Health professionals also reported mental health problems (schizophrenia, psychosis and dementia) and reproductive conditions (infertility, abortion and congenital

disabilities). Other cited conditions include rheumatic heart disease, congestive cardiac failure, high blood pressure, heart attack and heart failure.

Participants said:

"These are common conditions affecting many people in our neighbourhood. . . they include high blood pressure and heart disease, among others." (FGD 1, Participant 7, male, 51 years)

"I grew up in this area, developed a heart problem at a very young age, and later developed hypertension." (Participant 3, FGD 4, female, 45 years).

"Yes, mental health conditions, we have seen patients with schizophrenic disorders, and we have also encountered patients with depression, sometimes." (Participant 27, Individual Interview, female, 44 years).

Deaths of humans and animals from unknown causes. Participants in industrial settlements spoke about the mysterious deaths of animals (cattle, rabbits, fish and chickens) and humans whose causes were not ascertained. Although no tests were conducted to determine the cause of such deaths, they perceived that pollutants from industries and small-scale industrial and artisanal mines could be the cause.

Participants said:

"I only witnessed the death of several rabbits in one night. They died mysteriously from unknown causes, and other residents also lost their rabbits." (Participant 1, FGD 2, female, 51 years).

". . ... A resident of this mine compound passed away overnight, but no one knew the actual cause of her death. However, some suggested it could be hypertension." (Participant 4, FGD 5, male, 48 years old).

"There was an incident involving the death of fish at Mapanga Mine, which was linked to cyanide poisoning." (Participant 6, FGD 5, female, 40 years).

"Yes, I have heard about domestic animals and fish killed by unknown chemicals discharged into the environment. Chemicals commonly used in mining, such as cyanide and mercury, are the usual culprits." (Participant 37, Individual Interview, male, 56 years).

Unintentional chemical poisoning. Human and animal poisoning incidents have been linked to mercury and cyanide, which are commonly used in the mining and purification of gold ores. Some FGD participants reported that poisoning resulted in skin conditions, chest pain, breathing problems, lung problems, disability and death. According to some participants, poisonous pollutants adversely affect people and are suspected to cause poisoning in food animals, such as cattle, chickens, rabbits and fish. While some participants were unsure about the identity of the poisonous substances responsible for these animals' deaths, others were quoted as saying that cyanide and mercury were the principal suspects.

The participants said:

"Yes, I know one person who suffered from chemical poisoning. . .. . . I have been exposed to hazardous fumes from 2 companies that are doing carbon cyanidation of gold such that I now have breathing problems. (Participant 1, FGD 3, female, 42 years).

"Yes, incidents of cattle poisoning have occurred at the Roasting Plant in Gaika caused by chemical discharges into the environment a few years ago. . .. I have witnessed some artisanal miners with scaly skins and hands." (Participant 3, Individual Interview, female, 52 years).

"Yes, specifically, some people showed signs of suffering from this. For example, I saw people who came into contact with mercury shivering, especially when talking or wanting to write. So, I can say that I have encountered some of those people." (Participant 30, Individual Interview, male, 47 years).

Drivers of potentially toxic elements and cyanide environmental pollution

Industrial emissions and discharges. FGD and interview participants perceived industries and related facilities, such as mines, smelters, sewage treatment plants, and tailing dumps, as the leading pollution sources and contributors. Some participants said the lack of post-closure maintenance of tailings dumps compromised their integrity, and toxic pollutant discharges were responsible for environmental pollution. Participants said industries were responsible for discharging polluted effluents, particulate matter, noxious emissions and acid mine drainage.

Participants said:

"We have had a few incidents where some companies failed to manage their tailing dams or dump waste products. Of late, we have had a dispute between a ferro-chrome smelter and another adjust company that claimed that leachate was coming from the smelter containing chromium 6 ($Cr+^{6}$), which negatively affected their premises, so this is an issue under investigation." (Participant 15, Individual Interview, male, 50 years).

"Yes, environmental pollution in the form of particulate matter, water pollution, and gases from industry are public health issues. Some companies discharge their effluents into streams and rivers without proper treatment." (Participant 17, Individual Interview, female, 31 years).

"Yes, environmental pollution or contamination is a public health issue in the city. Industrial emissions pollute the air in the city, and a large amount of dust is produced. Wastewater from mines flows on the surface and ends up in water bodies around here." (Participant 34, Individual Interview, female, 36 years).

Failure to implement environmental management systems. Most participants perceived environmental systems as in place, but the problem primarily emanated from implementing these measures. However, small-scale artisanal miners were blamed for failing to follow environmental management systems and proper chemical handling methods, lacking adequate

mining skills and failing to rehabilitate the environment after mineral extraction.

Participants said:

"Yes, but the environmental management systems and practices to prevent and control potentially toxic metal and cyanide discharges and associated health problems at active/ closed mines and industries are there but often overridden by political elites." (Participant 15, Individual Interview, male, 50 years).

"I don't think they are adequate, especially for this city; most of the mines are operated by small-scale miners and do not have safety and health officers, so this means these people that are operating mines must implement environmental management systems, they are mostly people who are not informed or well versed with formal mining. . .. . .." (Participant 30, Individual Interview, male, 47 years).

"Environmental management systems at mines and industries seem to be associated with formal businesses, while artisanal and small-scale miners do not have or follow them. Standards and system enforcement must be improved. The Environmental Management Agency (EMA) and local authority seem ill-equipped and handicapped in enforcing good environmental management systems and practices in artisanal small-scale mining" (Participant 37, Individual Interview, male, 56 years).

Illegal and unregulated mining. The participants viewed rampant illegal and unregulated mining as the main drivers of environmental pollution. Artisanal small-scale mining (ASGM) must be better regulated, and environmental laws and policies are rarely enforced.

Participants said:

"Artisanal small-scale miners contribute significantly to environmental damage and do not rehabilitate the environment after removing the minerals from the ground. Chemicals such as mercury and cyanide have been associated with health problems in the city." (Participant 32, Individual Interview, female, 37 years).

"Artisanal miners pollute the environment by discharging mining chemicals and digging pits which they do not rehabilitate. The toxic metals from the dumps that they create leach into the soil and contaminate underground water or are washed into water bodies consumed by humans and animals, putting public health in danger." (Participant 40, Individual Interview, male, 31 years).

Factors associated with exposure to potentially toxic elements and cyanide pollution

Living near or working in polluted environments. The study participants perceived that it is riskier to reside near industries or polluted environments than people who stay far away, as they are more exposed to toxic pollutants in dust, particulates, acid mine drainage and wastewater.

Participants said:

"People who use Zibagwe River water bear the worst effects of pollutants from Kwekwe City. I have seen on several occasions that a mine located near the Central Business District (CBD) discharges acid mine drainage in the open, and this wastewater flows into a stream which drains into the Zibagwe River." (Participant 6, FGD 1, male, 54 years).

"Due to the proximity of our suburb to industries which produce a lot of dust and particulate matter, we are more vulnerable and exposed. . .. . . Even the smelter's waste product, such as slag, is blown away by the wind towards our residences, and at times, some particulate matter gets into our eyes. Also, some residents use contaminated effluent from industries to water their crops, so we are more exposed than other residents who stay far away from here." (Participant 7, FGD 1, male, 51 years).

"We always witness gas emissions from roasting gold by residents of the mine compound. Sometimes, it negatively affects people's respiratory systems, such that some residents develop breathing problems." (Participant 4, FGD 5, male, 48 years).

Rearing animals and growing crops on contaminated land. Participants said that some residents grew crops and vegetables at sites known or suspected of contamination, risking food contamination (crop and animal products) derived from such sites. Cattle and other livestock known to participants grazed near contaminated sites, such as smelters, tailing dumps and mines, which were suspected sources of potentially toxic elements and cyanide. Some participants viewed the soil in the area as contaminated by chromium, cyanide, mercury and other toxic substances.

Participants said:

"I have seen cattle near Indarama Gold Mine grazing near tailing dumps and pits. I also saw some cattle drinking contaminated water from a ferro-chrome smelter in an industrial area several times. I suspect that the water discharged from the company was contaminated with toxic substances. Residents in the area fetch water for their vegetable gardens near the smelter." (Participant 3, FGD 1, male, 64 years).

"Plenty of livestock such as goats and cattle graze and roam at mining sites in this area." (Participant 3, FGD 5, female, 46 years).

Use of contaminated surface water for household purposes. Most residents of industrial settlements used surface water (runoff, municipal wastewater and potable water from leaking plumbing fixtures, open wells, mine drainage and industrial discharges) when they experienced municipal potable water cuts or when their employers did not allow them to use potable water for gardening as a cost control measure. They also used the water for watering vegetables and bathing. However, some participants said they did not use water because they perceived it to be contaminated.

Participants said:

"We use raw sewage from blocked sewers to water our vegetables and crops. We divert the sewage flow to our gardens or fields whenever there are sewer blockages." (Participant 1, FGD 1, female, 49 years).

"We obtain the water from streams or stagnant water, especially during the rainy season like now. We are not allowed to use municipal water for watering vegetables because there are too many gardens, which is costly." (Participant 3, FGD 4, female, 45 years).

Consumption of fish from unreliable sources. Most FGD participants said that they bought or caught fish from mobile fishmongers from nearby streams. Although they believe that

fishmongers are unreliable sources of nutritional safety, their fish are affordable.

Participants said:

"Fishmongers sell catfish which they catch from raw sewage-contaminated streams. Fish swim against the tide from the Zibagwe River to the city. Of course, others catch the catfish from the nearby river, but most fish eaten in this area are caught from streams teaming with raw sewage." (Participant 3, FGD 1, male, 64 years).

"Normally, during the rainy season when streams are fully flowing, fish, especially catfish, tend to flow against the tide, and we catch them on our own." (Participant 2, FGD 2, female, 37 years).

Challenges in environmental and health care management systems

Inadequate law and policy enforcement. The participants expressed concern about inadequate enforcement by the responsible authorities to control environmental pollution in the city. Most participants said that although environmental laws were adequate, the EMA and the local authority needed the human, material and financial resources to control the problem. Participants perceived failure to deal with polluters to exacerbate the situation.

Participants said:

"It is a question of resources. As for the City Council, we are a bit low regarding resources, that is, vehicles and staff to enforce the law. Lately, we have made by-laws to ensure we have the legal tools to make people comply. On the EMA side, they enforce here and there, and Council officers conduct joint inspections with EMA officers in some of these companies, which I think is a good thing in enforcing environmental laws. However, the EMA has one inspector covering the whole Kwekwe district, a huge area. . ..for EMA to be effective, more officers must be employed to cater to all the aspects involved." (Participant 15, Individual Interview, male, 50 years).

"Yes, on policy issues, it is difficult to comment on my side. I feel that we have adequate legislation to govern these things, but challenges are coming regarding implementation. With the current economic status, it isn't easy to regulate certain things to their legal conclusions. Similar to the decommissioning phase, in which a miner and project implementer cover nothing regarding rehabilitation, it is easier for them to leave or neglect. If you try to make follow-ups on them, they will claim to be still active, that they will be just lying low, and some claim that they will come back later, but they will have gone, so it is difficult to make follow-ups." (Participant 25, Individual Interview, male, 52 years).

"Environmental management systems at active or closed mines and industries are there, but they are not adequately enforced by authorities to prevent and control heavy metal and cyanide discharges and associated health problems." (Participant 35, Individual Interview, female, 42 years).

Poorly equipped healthcare facilities and lack of resources. Participants said that public healthcare facilities in the city could not screen and test for non-communicable diseases. Specific problems cited include a lack of resources (diagnostic equipment, funding and skilled healthcare workers) and distant diagnostic and treatment centres.

Participants said:

"The biggest challenge faced is non-communicable diseases in the community, especially in their diagnosis at our clinic, caused by the shortage of resources, such as machines. For cancer, diagnosis is challenging if you do not have these machines to diagnose or perform a biopsy. Therefore, there is a need for these machines so that people can get access to early diagnosis of these non-communicable diseases at Council clinics as well". (Participant 23, Individual Interview, male, 29 years).

"The main challenge that we face is the non-availability of resources; for example, we have people who are living out of town, yet they are supposed to be treated within the city, so these people may not be able to travel to the city, so outreach programmes are needed. . ..at the end of the day these people are identified when they are very sick or bedridden so we need more community outreach programmes so that we can diagnose these people more." (Participant 24, Individual Interview, female, 32 years).

Lack of knowledge and awareness about non-communicable diseases. Key informants said that there was limited awareness and knowledge of non-communicable diseases in the community, and sick residents sought medical care when the disease reached advanced stages.

Participants said:

"I think the first challenge is lack of knowledge whereby our community is unaware of certain non-communicable diseases, how they develop over time and their impacts. Our communities are well versed with communicable diseases, such as cholera, which create an immediate impact. In contrast, most non-communicable diseases tend to take time and develop over longer periods, so knowledge about that is insufficient in our communities." (Participant 22, Individual Interview, male, 48 years)

"Challenges in the management of non-communicable diseases emanate from patients' delay in seeking help, which leads to delay in disease diagnosis, and lack of resources in the case of cardiovascular conditions, such as X-ray machines and medicines, which are expensive for patients" (Participant 27, Individual Interview, female, 44 years).

Proposed strategies and interventions

Improved environmental management measures and law enforcement. Participants proposed several environmental pollution preventive and control measures, including improved law enforcement, capacitating responsible authorities, training and skilling artisanal small-scale miners, imposing penalties on polluters, and banning or controlling poisonous chemicals used in mining. Participants also proposed improving the collaboration between regulatory authorities to complement each other in combating the problem of pollution and establishing a pollution monitoring framework for water, air and soil.

Participants said:

"Legislation and regulations should be enforced, policy implemented, monitored, and evaluated to reduce the health risks of potentially toxic metals and cyanide in the community" (Participant 3, Individual Interview, female, 50 years).

". . ... Artisanal miners must be educated and follow environmental systems. Even the EMA must perform a follow-up of these people, and miners must form groups whereby they are given training certificates after passing all aspects required to protect the environment. On the EMA side, one person is doing the job, which means he is overloaded, cannot do these follow-ups, and needs more workforce." (Participant 14, Individual Interview, male, 35 years).

"Measures required to reduce health risks related to toxic substances include substituting some highly poisonous substances like cyanide, mercury, and acids used in mining. More user-friendly chemicals and methods should be adopted or developed as control strategies. The regulatory authorities must be strict in implementing pollution regulations and laws." (Participant 34, Individual Interview, female, 36 years).

Improved healthcare facilities and measures. To address health problems, participants proposed several measures, such as upgrading healthcare facilities, capacity-building diagnostic laboratories, enhancing health promotion for NCDs, periodic screening of vulnerable groups for communicable diseases, adopting a multi-sectoral approach in combating non-communicable diseases, training personnel to manage non-communicable conditions and decentralisation of chemotherapy facilities to make them accessible to city residents.

Participants said:

"Provision of health education, state-of-the-art facilities, and machines for screening non-communicable diseases. Periodic screening and testing of vulnerable groups like mine workers, artisanal miners, and people living around industries and mines." (Participant 7, Individual Interview, female, 54 years).

"A multi-sectoral approach is needed in combating non-communicable diseases, revising policy on non-communicable diseases, enhancing health on education non-communicable diseases, and improving diagnostic techniques." (Participant 11, Individual Interview, female, 28 years).

"I think we need adequate equipment and a workforce. There is also the need for decentralising chemotherapy facilities because, as it is now, if someone is diagnosed with cancer, they must go to Harare, Bulawayo, or Anderson Hospital for treatment. They start looking for money for transport alone, causing further patient treatment delays" (Participant 29, Individual Interview, male, 38 years).

Discussion

The themes that emerged from the study included non-communicable diseases related to potentially toxic elements and cyanide pollution, drivers of PTE and cyanide pollution, factors related to pollution exposure, challenges in environmental and healthcare management systems and strategies to mitigate or adapt to the impacts of toxic pollutants. There was consensus and concern among study participants that toxic pollutant risks posed a threat to public health. Although the study findings can not be replicated or generalised to the other population groups, they are critical in providing insight into the community's health risks. This dovetails with findings by Dettori and others in their study,[23] which showed that perceived risks are sometimes in line with the real ones; however, it is critical to provide affected communities with objective tools to enable them to interpret the risks themselves. It must be emphasised that while participants perceive and link specific toxic pollutants to health conditions that affect them, the aetiology of pollutants is complex and non-specific because the conditions can be attributed to other environmental agents.

The study participants pointed out that toxic pollutants contributed to disease causation in Kwekwe City. They reported health conditions that included cancers, respiratory ailments, mental and reproductive conditions, heart and kidney problems and chemical poisoning. Some previous qualitative studies on environmental pollution reported these health conditions mentioned by participants in Kwekwe City. Ashworth et al[24] observed that urban residents exposed to traffic and industrial emissions are prone to such health conditions.[24] While acknowledging the limited studies of this nature, Bena et al[4] also reported about two groups of residents that they studied, which differed on the link between atmospheric pollution and health conditions such as respiratory conditions, cancer, leukaemia and congenital disabilities that were perceived to be associated with waste-to-energy plant operations from inception.[4] The study found that after 3 years of operation, the between-group difference diminished over time, and the reduction was statistically significant for all of the above illnesses except respiratory diseases. Therefore, while the manifestations of non-communicable diseases are perceived to be inherent where industrial pollutants are endemic, the use of proper diagnostic tools provides scientific evidence and verifies the problem. Irenge et al[14] found that workers at a mine in DRC experienced health conditions such as chronic pulmonary diseases, tuberculosis, insomnia, gastrointestinal disorders and headaches, which required raising awareness and adopting accessible protective measures.[14]

The study participants perceived drivers of PTE pollution to include industrial emissions and discharges, failure to implement environmental management systems and illegal mining. Industries and related facilities in Kwekwe City, including smelters, gold processors, artisanal and formal mines, sewage treatment plants and tailings dumps, were cited as the primary sources of toxic pollutants. Some previous studies confirmed the role of industries in discharging toxic pollutants into the environment.[5,23] Industries contribute significantly to shaping environmental risk perception in populations exposed to them, which explains the apprehension of people who live near the facilities about industrial catastrophes and long-term damage to health.[4,23] However, exposed populations' perceptions are not always accurate. Following residents' concerns about the poor environmental quality in their residential area, analyses by the Regional Environmental Protection Agency of Sardinia excluded the presence of pollutants in the environment, and health authorities reported no excessive disease cases.[23] In this study, industries were cited as responsible for failing to implement proper environmental management systems and engaging in illegal

and unregulated mining activities in the study area. Muindi et al[5] asserted that sensory perception of pollution includes observing a cloud of smoke over an area, pungent smells from factories and dumpsites, and soot falling on people and buildings.[5,24] While sensory perceptions are critical in identifying sources, exposure pathways, and responses, the dependence on them by communities may be misleading, especially where pollutants are invisible and odourless.[5,25] Participants pointed out that there were widespread illegal and unregulated mining activities in the study area, and this correlated with a study on artisanal small-scale mining (ASGM) in Kadoma and Shurugwi, which found that exposure to mercury, chemical dust and toxic gases from blasting was the main workplace environmental hazard.[16]

Several factors associated with exposure to pollutants cited by participants in this study included living near polluted environments, rearing animals and growing crops on contaminated land, using contaminated surface water and consuming fish from unreliable sources. Living close to or near the pollution source increases perceived health risks.[4,23] At the same time, urban agriculture contributes to urban food supply, and harmful industrial pollutants, such as heavy metals and trace elements released into agricultural soils, pose environmental and public health risks.[26] Other contributing factors include health risks from growing crops and rearing animals on contaminated land and community exposure to toxic pollutants from consuming contaminated fish. Some authors agree that growing crops or vegetables on contaminated land or using contaminated water leads to the accumulation of heavy metals in plants, which can be transferred to humans through food chains, thus potentially endangering human health.[26,27] The participants said that they used surface water in the form of runoff, leakage from municipal supply lines, wells, mine drainage and sewage from blocked sewers for various purposes, including drinking, washing and watering crops. The risk of surface water contamination cannot be excluded in areas with several sources of pollution. Contaminated urban surface water can contain toxic pollutants that can cause diseases in humans.[28] Most FGD participants indicated that they bought fish from mobile fishmongers who claimed to get them from reliable sources, including a local dam, Dutchman's Pool, which is known to be polluted by municipal sewage discharges from Kwekwe City. Exposure to contaminated fish can result in bioaccumulation of heavy metals in humans, which leads to acute or chronic poisoning.[29,30]

Participants cited several environmental and healthcare management challenges, including inadequate environmental law and policy enforcement, poorly equipped and financed health facilities, and a lack of knowledge and awareness of non-communicable diseases in the community. To mitigate environmental problems, participants proposed a gamut of interventions such as banning, restricting and substituting the use of toxic chemicals such as cyanide and mercury; improving collaboration between regulatory authorities so that they complement each other in combating pollution; establishing an environmental pollution monitoring framework; and training artisanal miners proper mining methods and chemical handling and management. According to Faroque and South,[31] laws and policies are critical for addressing threats to biodiversity protection. However, they are not always well enforced on the ground, which can worsen environmental pollution and degradation, leading to high morbidity and mortality in communities.[31] The ASGM sector needs to be formalised by adopting policies that regulate it and funding it as a prerequisite for risk mitigation.[16] One of the most critical measures in the ASGM is providing technical support on safety precautions and guidance on basic standard operating procedures, which is critical in mitigating safety risks in artisanal gold mining.[16,32]

Occupational training in ASGM mining can improve miners' skills while creating the opportunity for economic benefits,[16] thereby facilitating behaviour change. In Ghana, occupational health and safety training correlated positively with small-scale miners' health and safety practices.[16,33] The use of a hierarchy of control measures such as reducing, substituting and restricting the use of some toxicants like cyanide and mercury in mining can be beneficial in mitigating the effects and impacts of these chemicals; however, in the absence of affordable and readily available alternatives, this may not be feasible or practical. Singo et al[16] said that due to the low uptake of retort use (after training), they recommended using mercury-free technology in ASGM.[16] Study participants proposed many measures to address healthcare problems associated with toxic pollutants, including upgrading healthcare facilities, capacitating and building diagnostic laboratories and periodic screening of residents, among other strategies. However, human biomonitoring through regular testing of exposed and vulnerable subpopulations of toxic substances, such as mercury in human hair, blood and other fluids, may enhance public health through early detection and treatment of patients.[34,35] According to study participants, there is a significant lack of community knowledge and awareness of non-communicable diseases. This mirrors the knowledge gap in non-communicable diseases in Zimbabwe and Africa, worsened by persistent health system challenges such as human and financial resource constraints. Therefore, there is a need for a more comprehensive health promotion strategy to prevent these diseases.[36,37]

According to the United Nations Environment Programme (UNEP), **environmental pollution** significantly contributes to non-communicable diseases (like cancer and respiratory illnesses) and approximately **9 million deaths** annually.[3] In partnership with UNEP and the World Meteorological Organization (WMO), the WHO established a coalition on health, environment, and climate change to reduce the estimated 2.6 million deaths yearly from air pollution and other

environmental risks. Spurred on by these initiatives, there is a compelling need to address these issues by operationalising linkages between science and policy, international collaboration, and robust legislation. Also, deriving from the One Health approach,[38] the authors of this study sought to contribute to transitioning to a pollution-free planet by raising awareness of pollution's impacts and solutions by highlighting the significant roles stakeholders can play. Pollution is a major, overlooked global health threat that was responsible in 2015 for an estimated 9 million deaths and substantial economic losses.[3] This study was also motivated by and dovetailed with the Sustainable Development Goals on Health (SDG 3), SDG Target 6.3 on improving global water quality advocates for reducing pollution, eliminating dumping, and minimising the release of hazardous chemicals and materials, while the SDG 11 on sustainable cities, provides a massive opportunity for addressing environmental pollution and related health impacts that are driving countries to take action.[39] Research on toxic pollutants contributes to achieving SDG target 3.9. 1, which advocates for substantially reducing deaths and illnesses from air pollution.

This study's results were based on self-reported data, which may be subject to recall and response biases. Therefore, the findings must be interpreted cautiously. However, measures were taken to minimise these biases. Although the study results are not generalisable and replicable to other populations, they provide valuable insights for policymaking and intervention strategies.

Implications of the Study

This study provided useful insight into public health risk perceptions of PTE and cyanide pollution in a low-income country like Zimbabwe, where the government is more focused on industrialisation and wealth creation, albeit at the expense of the environment and public health.[2,3] This problem is prevalent in many low-income countries, and industries must be effectively monitored and regulated to achieve SDG 3 on the environment and human health.

This study has implications for researchers, policymakers and stakeholders. Without diminishing the significance of this qualitative study, researchers need to conduct quantitative studies, which give generalisable and replicable results to the general population or other population groups as part of research triangulation to supplement and enrich these findings. The high-risk perception expressed by most participants in this study calls for future epidemiological studies to focus on biomonitoring of toxic pollutants in residents, especially in vulnerable subpopulations such as industrial workers, artisanal miners, gold processing workers and residents of industrial settlements, to ascertain the adverse public health impacts.

For policymakers, it is critical to review current environmental legislation and interventions regarding the use of cyanide and mercury in the extraction and processing of minerals. These chemicals must be reduced or substituted to protect the environment and public health. Regulatory enforcement must be sufficiently applied and strengthened to deter and control illegal environmental activities. Regular screening of exposed and vulnerable sub-population groups must be implemented to detect non-communicable diseases and initiate early treatment. This calls for the capacitation of health facilities regarding the provision of sufficient diagnostic and treatment equipment and technology.

Stakeholders, including the government, industry and citizenry, must address the industrial pollution problem at multisectoral levels. Following up on the first-ever WHO conference in Geneva on air pollution and health held in 2018, attended by representatives from governments, intergovernmental organisations, civil society, philanthropy, research and academia, there is a need to build multi-sectoral synergies between human health, climate change, the energy sector and growth priorities. For example, capacitating industries with clean production technologies to reduce pollution must be recognised by governments through incentives like tax cuts or rebates. At the same time, citizenry participation in environmental conservation and pollution mitigation and adaptation needs to be promoted and escalated to raise awareness among the public so that they protect public health from the adverse impacts of pollution.

Conclusions

The study indicated that FGD and interview participants converged on many aspects of the city's environmental pollution and health risks. Toxicants such as mercury, cyanide and chromium were cited in their narrations as the principal pollutants in disease causation. A pollution surveillance programme in the city is needed to monitor pollution trends and institute corrective measures to protect the environment and public health. Environmental rehabilitation and cleansing must be prioritised to deal with the legacy and current pollution problems. Chemicals such as PTEs are non-biodegradable and accumulate in the environment; hence, measures must be implemented to decontaminate the environment.

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Author Contributions

SN conceptualised the study in partial fulfilment of the requirements of the PhD study. NSM is the Principal Promoter of the PhD study, whereas AGM, SEM, and ANT are Co-promoters. The 3 co-promoters contributed by guiding the first author in preparing the manuscript. All authors read and approved the final manuscript.

Research Ethics and Consent

The University of Venda Ethics Committee approved the research under Registration Number FHS/22/PH/05/2306 and the Medical Research Council of Zimbabwe under

Approval Number MRCZ/A/2944. Consent to proceed with the study in Kwekwe City was obtained from gatekeepers, which included the local authority, heads of medical facilities and participants. Participation in the study was voluntary, and participants signed consent forms before data collection.

Data Availability Statement

The datasets generated from the study supporting this article's conclusions can be obtained from the corresponding author upon the article's completion and publication.

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