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Analysis of Atlanta Residents' Knowledge Regarding Heavy Metal Exposures Associated with Urban Agriculture

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a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract

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Urban gardens are often recognized for the benefits they provide to communities. Gardens can improve nutrition and food security, as well as promote community development and social capital. Yet, urban soils are often at risk of heavy metal soil contamination because of their proximity to industrial sites and areas of high pollution. Contaminants such as lead, arsenic, and slag are particularly harmful in urban gardens and may be hazardous to one's neurobehavioral-cognitive performance and overall health outcomes. Gardeners face increased exposure to these soil contaminants because of their regular contact with soil and consumption of produce grown in their gardens. However, previous studies have indicated that community gardeners are frequently unaware of the dangers heavy metal soil contamination poses or the potential remediation strategies that exist. In August of 2018, hazardous levels of heavy metal soil contamination were detected in West Atlanta gardens. This study seeks to better understand the awareness of Atlanta community members about the existence of soil contaminants in their gardens and their opinions on access to soil testing and remediation resources. Special attention was paid to differences in knowledge across racial groups and household incomes. The study was community-based and took place through surveys as well as follow-up interviews with several participants. It also included an outreach component through the distribution of educational materials and an opportunity to have soil tested at the Atlanta Science Festival. Survey participants indicated that they were concerned about the potential health effects of contaminants in soil, yet were unconcerned with produce in their gardens even if they had not previously had their soil tested. Findings also revealed that gardeners' education on sources of contaminant exposure are often very low and that African American participants frequently lack confidence in recognizing negative health effects of heavy metals. Participants also provided insight into their generally low levels of knowledge surrounding methods of soil remediation. The information gained from this study can be used to guide outreach efforts by targeting the most vulnerable communities and efficiently improve the safety of urban gardeners, especially by improving the overall accessibility of soil testing and remediation.

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1. <u>INTRODUCTION:</u>

1.1. ROLE OF URBAN AGRICULTURE IN COMMUNITIES:

In 2014, 54% of the world's population lived in urban areas, and this proportion is projected to increase to 66% by 2050 (United Nations, 2014). As a result, urban agriculture is expected to become more prevalent, often in the form of community gardening. In 2008, roughly one million households in the United States were involved with some community gardening effort (Kessler, 2013). In most community gardens, an area is split among individuals or families who each take care of their own plot of land. Community gardens are especially common in urban areas, where land is generally more condensed and fewer individuals have ownership over their own sufficient plots of land (Okvat & Zautra, 2011).

The rise of urban agriculture through municipal farms and household gardens has provided a strategy to cope with the food needs of a rapidly growing population (Brown & Jameton, 2000). Shared gardens not only provide communities with food and engage them in the food production process, but also promote personal health, environmental stewardship, and civic engagement (Krasny & Tidball, 2009). Urban farms have been found to have many health benefits, including better nutrition and food security, improved community development through education and skills training, stronger social ties, and enhanced local sustainability (Wakefield et al., 2007). Moreover, community gardens can improve the sustainable infrastructure of cities by providing green space and reducing carbon emissions released by food transportation (Meharg, 2016).

Community Health and Diets. On average, individuals involved with community gardening efforts have an increased likelihood of consuming fruits, vegetables, and other crops grown from their gardens. Previous community-based studies have cited an increase in the consumption of fruits and vegetables and a decrease in the consumption of packaged foods among individuals with access to an urban garden (Wakefield et al., 2007 McCormack et al., 2010, Alaimo et al., 2008; Litt et al., 2011). Increased consumption of fruits and vegetables is known to improve overall health and prevent diseases and other negative health outcomes, such as childhood obesity (Castro et al., 2013, Barnidge et al., 2013). Individuals involved in urban agriculture were also more likely to cite the importance of fruits and vegetables in one's diet (McCormack et al., 2010, Barnidge et al., 2013). Participants directly involved in urban growing were also less likely to use pesticides, which are toxic and can result in acute symptoms such as nausea and skin irritation, as well as long-term illnesses such as asthma and cancer (Wakefield et al., 2007).

Urban agriculture has also resulted in improvements in food security for many communities. The use of garden-grown food has improved cost-savings by reducing the need to buy produce at grocery stores (Wakefield et al., 2007). This is especially significant for low-income households which may not have sufficient resources to purchase food at grocery stores. Community gardens also provide increased and direct access to healthy food sources in place of cheaper options at supermarkets, which may not have as high nutritional value (Winne, 2008). Improved food security and nutrition reduce environmental health inequalities, and promote environmental justice by providing a secure source of healthy produce to often disadvantaged communities (McIlvaine-Newsad & Porter, 2013).

Community Development and Social Capital. Shared gardens provide an outlet for community members to engage with each other on a regular basis as they share tools, cultures, and different ideas. Gardens allow community members to share their culture, education, and overall social morale, and they increase the area of greenspace in an urban area, where such space is often limited (Lawson, 2016). This is important because proximity to greenspace may promote social contact between neighbors in a community by providing a common space in which to gather (Sullivan et al., 2004). Shared gardens also improve community pride (Wakefield et al., 2007).

Alaimo et al. (2010) surveyed community members in Flint, Michigan and determined that involvement with community gardens increased perception of social capital across a variety of measures. Perception of trust and social support, as well as sense of responsibility for the neighborhood and satisfaction with the neighborhood was higher among community gardeners than non-gardeners (Alaimo et al., 2010). Similarly, previous studies have found that community gardeners often work collaboratively with each other and frequently share gardening tips and ideas among their network (Holland, 2011; Wakefield et al., 2007).

Historic Westside Gardens Atlanta. Historic Westside Gardens Atlanta, Inc. (HWG) was created in 2008 to provide individuals in West Atlanta with the resources and education necessary to develop and maintain community garden hubs. These gardens allow local families to cultivate their own produce in order to reduce food expenses and encourage the consumption of more nutritious foods. The gardens may also help West Atlanta residents build a more cohesive social community, interact with the community economy, and further control their personal dietary habits. Because income disparities are generally high in Atlanta, HWG has a particular focus on working with low-income individuals and families who reside in west Atlanta.

HWG allows individuals and families to create gardens in their private homes through the Urban Home Food Gardening initiative. Enrollment as a home gardener in HWG is free, and individuals who enroll are provided with a raised bed, soil, and seeds to begin their garden. Garden Angels are residents in West Atlanta neighborhoods who are hired to lead Atlanta neighborhoods towards these goals. Garden Angels assist home gardeners in selecting crops to meet their needs, teach them gardening and composting techniques, and help them to solve any challenges that may arise. Individuals who lack an appropriate space for food can join a Community Gardening Hub, a shared space for members to garden.

In 2018, HWG encompassed seven different garden spaces, including three Community Gardening Hubs, two school gardens, one garden for seniors, and one garden for a local youth center. 143 home gardeners participated. Gardeners who do not eat all of their produce have the opportunity to bring the food to Westside Growers' Market where it is sold to other community members. The goal of Westside Growers' Market is to provide access to affordable, community-grown produce in order to strengthen the local-economy and improve the food security and nutritional outcomes of Westside Atlanta residents.

1.2. SOURCES & HEALTH EFFECTS OF HEAVY METAL SOIL CONTAMINANTS:

Because of the nature of cities, urban gardens are more likely than suburban and rural gardens to be near areas with high pollution, such as industrial sites and roads (Kim et al., 2014). Municipal soils typically have higher levels of heavy metal contaminants than non-municipal soils due to human activity, such as fossil fuel use, waste incineration, and construction with heavy metal-based paints (Mitchell et al., 2014). High concentrations of heavy metals are often the result of human industrial development, such as mining and smelting (Tchounwou et al., 2012).

Through gardening, individuals may face increased exposure to these soil contaminants. Urban gardeners are at risk of exposure to heavy metal contaminants through inhalation of soil particles and contact of soil with the skin (Kim et al., 2014). They may also ingest soil when eating produce from their gardens (Kim et al., 2014). Soil contamination may significantly alter the ability to grow healthy and safe food in cities (Wortman & Lovell, 2013). The health effects of heavy metals are generally chronic because exposure bioaccumulates over the long-term (United States Department of Agriculture, 2000). Lead, cadmium, mercury, and arsenic are four heavy metals (metals with a specific density greater than 5 g/cm^3) often associated with soil contamination (Järup, 2003). This study focuses primarily on lead and arsenic, with slag as a main source of exposure and contamination in gardening soils.

Slag. Slag consists of metal waste scraps created during the smelting or refining of metal ore. Large quantities of slag are especially likely to be dumped in areas where iron and steel mills have been historically located (Piatak et al., 2014). Slag can contain hazardous heavy metal contaminants, such as lead and arsenic. These contaminants may leach into soil from slag deposits, resulting in severe risks to the environment and human health (Piatak et al., 2014).

Lead. Lead pollution is often associated with anthropogenic sources. For instance, it is common in areas with high rates of fossil fuel burning and industrial production (Tchounwou et al., 2012, United Nations Environment Programme, 2010). Because human activities such as these are common in cities, lead is frequently regarding as the most common soil contaminant in cities, and urban soils are particularly responsible for childhood lead exposure (Brown et al., 2015; Finkelstein et al., 1998; Gonick, 2008). In urban environments, lead may be orally ingested through the consumption of produce grown in lead-contaminated soils, or it may be ingested through finger-to-mouth contact and dermal exposure in children who have been playing in lead-contaminated soils (Boyd et al., 1999). Lead may also enter the household when gardeners wear shoes into their homes or do not thoroughly wash their hands (Kessler, 2013).

Frequently consuming plants grown in lead-contaminated soils may put individuals at risk of severe health outcomes (Hettiarachchi, 2004). The nervous system is severely impacted by lead. Lead has severe health consequences, especially for neurobehavioral-cognitive performance, such as irritability, memory loss, antisocial behavior, and reduced intelligence quotient (IQ) and attention span (World Health Organization, 2018; United Nations Environment Programme, 2010). Infants, children, and babies of pregnant women are most susceptible to negative health effects of lead, even when infrequently exposed (Centers for Disease Control and Prevention, 2001). The Centers for Disease Control and Prevention (CDC) has determined that there is currently no known safe level of lead exposure.

Arsenic. Arsenic is a heavy metal often associated with the production of agricultural chemicals, such as insecticides and herbicides, as well as the production of many human and veterinary medicines (Tchounwou et al., 2012). It may also be released from other anthropogenic sources, such as smelting, mining, and power plant operations (Agency for Toxic Substances and Disease Registry, 2007). Because of this, soils near historical mining and smelting sites are likely to contain higher concentrations of arsenic (Agency for Toxic Substances and Disease Registry, 2007).

Like lead, arsenic is exposed to humans through both oral ingestion and finger-to-mouth contact (Tchounwou et al., 2012). Produce grown in contaminated soils may be ingested if gardeners do not thoroughly rinse it before consumption. Exposure to arsenic is linked to increased risk of cancer (Tchounwou et al., 2003), neurological and behavioral conditions, diabetes, and hearing loss (Agency for Toxic Substances and Disease Registry, 2000; Centeno, 2005). Other symptoms of exposure include nausea, diarrhea, extreme fatigue, vomiting, and skin warts (Agency for Toxic Substances and Disease Registry, 2007). Many organ systems, including the cardiovascular, respiratory, nervous, and gastrointestinal systems, are at risk when exposed to high levels of arsenic (Tchounwou et al., 2003).

1.3. COMMUNITY RESPONSES TO HEAVY METAL SOIL CONTAMINANTS:

Remediation of Soil Contaminants. Heavy metals can generally remain in soils indefinitely without degrading (USDA, 2000). Therefore, contaminated soils and crops must be treated and managed in order to remove heavy metals and reduce the risk of negative health effects for gardeners. For instance, through phytoremediation, certain plants grown in contaminated soils can extract and remove heavy metals from soil (Hettiarachchi, 2004; Raskin et al., 1994). Other remedial management options include surface capping, encapsulation, electrokinetic extraction, soil flushing, chemical immobilization, bioremediation, and soil washing (USDA, 2000; Liu et al., 2018). These techniques employ both in-situ strategies, which treat soil on site and are usually cheaper options, or ex-situ strategies, which require contaminated soil to be removed from its original site and transported to a secure treatment facility but at a higher cost (Liu et al., 2018). Remediation can take place through physical, chemical, electrical, thermal, or biological treatment options (Liu et al., 2018).

However, these treatment processes are often costly and difficult to carry out (Hettiarachchi, 2004). As a result, the most effective remedial processes must be based on a combination of factors, including site geography, budget, and timeframes (Liu et al., 2018). On an individual level, consumers can reduce ingestion of heavy metals in their produce by peeling root crops, removing leaves of plants, and washing produce thoroughly prior to consumption (Kessler, 2013).

Community Awareness of Soil Contaminant Risks and Remediation. Despite the extremity and variety of health risks associated with heavy metals, community awareness of soil contaminant risks and remediation sources is limited, partially due to lack of online and educational resources, which provide such information (Witzling et al., 2010). Kim et al. (2014) administered 70 surveys and conducted 18 semi-structured interviews with gardeners in Baltimore, Maryland, ultimately finding that while most gardeners were aware of lead as a soil contaminant, they were less aware of other trace elements that could contaminate their soils, such as arsenic and cadmium. This lack of awareness may be especially pronounced in low-income and/or minority communities. In another interview-based study by Johnson et al. (2016), fewer than 50% of gardeners in predominantly African American and Latino communities were aware of and concerned about the potential health effects of lead in their soil. Similarly, 48.4% of interviews with community gardeners in St. Louis, Missouri indicated community concern for heavy metals in soil (Wong et al., 2017).

Previous research has also studied the extent to which urban and/or community gardeners are aware of resources for soil remediation. A survey of 111 respondents from Tacoma, Seattle, and Kansas City found that urban gardeners had minimal confidence in their knowledge of and proper access to resources for soil contamination (Harms et al., 2013). Moreover, soil testing for urban gardeners is limited, and many urban gardeners lack appropriate knowledge regarding methods for finding a soil contaminant testing lab (Witzling et al., 2010). Without awareness of soil contamination risks, community gardeners may be unlikely to seek soil remediation.

Environmental Justice Risks. Municipalities have vast differences in equity between community members (Wachsmuth et al., 2016). Therefore, social equity is an important facet that can either support or undermine urban sustainability and health. Sampson (2017) states that "urban sustainability requires an additional theoretical focus on the social structure of cities and their neighborhoods."

Keeler et al. (2016) recognizes differences in exposure to environmental harms and unequal distribution of resources as two factors that influence the equity of urban environmental landscapes. These differences may be a result of varying socioeconomic statuses, gender, race and/or ethnicity, age, and family structure (Cutter et al., 2003). Differences in these areas may affect one's ability to cope with environmental hazards, including hazards of soil contaminants in the built environment. In many cities, heavy metal contaminants and industrial hazards have already afflicted certain racial groups disproportionately (Crowder, 2010). For instance, predominantly low-income, African American communities in Chicago, Illinois and Flint, Michigan have experienced exceptionally high levels of childhood lead poisoning (Sampson, 2016; Hanna-Attisha et al., 2016).

1.4. SOCIAL SCIENCE IN ENVIRONMENTAL HEALTH STUDIES:

Social science provides a forum for moderators to gather a variety of thoughts and opinions in order to better understand how a community feels and behaves as a whole. It allows participants to engage in dialogue with each other and share ideas. Larger focus groups provide an opportunity for more dialogue from each individual but a narrower variety of participants (Morgan, 1996). Individual interviews may also be beneficial because researchers can ask more specific questions about personal matters (DiCicco-Bloom & Crabtree, 2006). For this reason, individual interviews are helpful when attempting to learn more personal, private information, such as information about health or income.

Lobdell et al. (2005) suggests that social science can play a key role in environmental health studies, especially those which seek to identify risk perceptions of environmental exposures and develop awareness for limiting exposure to harmful environmental contaminants. For instance, Kaiser et al. (2015) used a series of focus groups to research what residents in low-income neighborhoods perceived were the greatest threats of urban agriculture to their personal health and safety. Qualitative data may also play a particularly important role in understanding the beliefs, activities, and behaviors that put a community at higher or lower risk of adverse environmental exposures (Scammell, 2010).

In the past, many researchers have not reported information or educational materials to study participants to promote environmental health literacy (Brody et al., 2014). However, incorporating education and social science into environmental health studies can also help to reduce environmental inequalities and promote positive change in environmental health through policies and public awareness (Hoover et al., 2015). Social science studies through focus groups, interviews, and surveys may help interviewers better understand what obstacles a community faces in improving its environmental health conditions (Lobdell et al., 2005). Additionally, such studies provide an opportunity for researchers to educate community members about environmental health risks and potential for opportunities for improvement. This study sought to integrate educational opportunities in order to provide community members and urban gardeners with these benefits.

2. REASONS FOR STUDY:

Given their social, economic, and environmental benefits, urban agriculture and community gardens are rapidly growing more popular across the United States (Lawson, 2016). However, many gardeners and farmers are still unaware of potential pollutants because of a significant lack of education and monitoring. Pollutants and contaminants are unequally distributed across cities, and certain neighborhoods may not have equal access to soil screening resources. Keeler et al. (2016) suggests that many studies have focused on benefits of urban nature, but few studies have analyzed the potential consequences. Therefore, there is a need for extended research on potential disservices of nature, such as adverse health effects, in order to better determine the true value of nature in urban environments. Scientists and researchers, such as Andrew Meharg (2016), have acknowledged the increasing need for systematic monitoring and community awareness of soil contaminants in cities.

Further consideration should also be paid to differences in how urban ecosystem services affect residents of varying socioeconomic backgrounds (Jennings et al., 2016). Past research has examined environmental justice issues in cities by studying the unequally distributed benefits of ecosystem services, but few have studied the unequally distributed consequences (Jennings & Johnson, 2015; Agyeman et al., 2003). Keeler et al. (2016) calls for "increased investment in research and decision support to help determine the right mix of nature-based solutions in the right place at the right scale to deliver benefits to communities and households that need them most."

Kim et al. (2014) used a series of surveys and interviews to analyze knowledge of community gardeners regarding heavy metal soil contamination risks and resources in the

Baltimore, Maryland area, but noted that these findings may be unique to Baltimore. Therefore, further studies are needed in other urban areas, such as Atlanta, in order to validate these findings and determine whether similar conclusions can be drawn gardeners in other cities. For this reason, this study was administered to urban gardeners throughout the metro-Atlanta area (within a 25-mile radius of Atlanta). The study was administered partially through a partnership with HWG, and many study participants were gardeners through HWG. However, other urban gardening organizations were also contacted to participate in the study, such as Lake Claire Community Land Trust, Hopewell Community Garden, and Truly Living Well Center for Natural Urban Agriculture.

Previous research conducted by Dr. Eri Saikawa and Sam Peters (2019) sampled 19 sites in West Atlanta and 4 additional sites in other locations throughout Atlanta. Of these 23 sites, 7 sites were found to have lead contamination. Around the same time, unusual materials were discovered by the Garden Angels at HWG in August of 2018. Researchers at Emory University and the Environmental Protection Agency (EPA) tested and identified these materials as slag containing toxic levels of heavy metals. The slag was later assessed by the EPA, Georgia Department of Health, HWG, and Dr. Eri Saikawa's research lab throughout the site to better understand its potential scope in Atlanta. In November of 2018, the EPA received funding to clean sites with these contaminants. Soon after, this project was created to better understand the knowledge of community members about the existence of soil contaminants in their urban gardens and neighborhoods.

2.1. OBJECTIVES:

The objectives of the study were as follows:

- To determine the main concerns of Westside Atlanta residents regarding health and gardening, with a focus on produce eaten from the gardens and the direct health effects of exposure to heavy metal contaminated soil
- To educate community members so they can better detect health effects of heavy metals in soils and understand how to reduce these health effects by engaging in safe gardening practices
- To understand whether community members know which resources are available to them to reduce negative health outcomes associated with slag, lead, arsenic, and other soil contaminants
- To engage community members with resources available to them, find out further resources they need, and determine other methods of improving soil and community health in west Atlanta

The overall goal of the study was to analyze the knowledge of Atlanta residents regarding possible soil contamination in their homes and community gardens. The study was conducted with the understanding that if soil contamination exists, the research could determine ways that to improve soil and community health. Special consideration was given to using the research as an outlet for educating community members on heavy metal exposure, dietary-related personal health, and soil health (the capacity of soil to sustain plants, animals, and other components of the ecosystem). These efforts culminated with an opportunity for community members to test their soils for heavy metal contaminants for free at the Atlanta Science Festival on March 9th, 2019 at HWG's Urban Fresh Garden.

2.2. HYPOTHESES:

Based on past studies and knowledge of common gardening practices in Atlanta, I hypothesized the following:

1. Individuals with higher average annual household incomes would have more knowledge of the health effects of heavy metal soil contaminants. This hypothesis was made under the assumption that individuals with lower incomes may be more likely to live in areas with heavy metal contamination, yet have fewer years of education.
2. Individuals with higher average annual household incomes would have more knowledge of possible resources to remediate heavy metal soil contaminants. This hypothesis was made under the assumption that individuals with lower incomes may be less likely to live in areas with access to remediation resources and have fewer years of education.
3. Individuals with lower average annual household incomes would more readily eat produce from the gardens. This hypothesis was made under the assumption that individuals with lower average annual household incomes may be less aware of the health effects of heavy metal soil contaminants and possible remediation strategies.
4. Individuals participating in community gardens, such as HWG would be more aware of health effects of heavy metal soil contaminants and possible remediation strategies

than individuals participating only in private home gardens. This hypothesis was made under the assumption that community gardens may provide more opportunities for education regarding gardening and urban agriculture.

3. METHODS:

3.1. STUDY OVERVIEW:

51 surveys were collected from January to March 2019 with gardeners throughout the Atlanta area, with a focus on gardeners from HWG. The survey had 37 questions and asked a combination of general demographic and personal knowledge/awareness questions. The anonymous survey took about 10-20 minutes for each study participant to complete. There was a combination of multiple choice and open-ended, short answer questions on the survey. Demographic questions asked information such as age, race, number of children in the household, average annual household income. At the end of the survey, participants were given the opportunity to provide their contact information for follow-up, optional, individual interviews. Each interview was recorded with the permission of the interviewees, and all interviews were transcribed for analytical purposes. Interviews were conducted either in person or by phone, and nine interviews were conducted in total.

Both paper surveys and online surveys were offered to gardeners in order to reduce a bias in data for potential participants who did not have access to a computer and/or internet. Study participants and gardening organizations were contacted through a variety of methods in order to increase the diversity of potential participants, in terms of race, income, and type of garden participated in. The American Community Gardening Association's database of community gardens in Atlanta was used to recruit many of the community gardeners who participated in the study. 9 of the 48 community gardening organizations contacted through this method responded to the survey (an 18.75% response rate). 21 respondents were recruited through this database.

Studies were also administered at weekly HWG meetings and the Atlanta Science Festival. Respondents from the HWG meetings were a combination of both community and home gardeners, and respondents from the Atlanta Science Festival were primarily home gardeners. 8 survey respondents were gardeners through HWG, and 26 survey respondents were recruited through the Atlanta Science Festival Event. Some respondents were recruited from more than one method. Some respondents did not complete the entire survey due to time and interest constraints.

To be eligible to participate in the study, participants were required to be at least 18 years old, residents in Atlanta, and actively engaged in either a community garden and/or a home garden. Written consent forms were signed by each participant before the study was administered. Participants were informed that their names would not be directly associated with any quotes included in the study. Garden Angels, representatives from HWG who help lead community and residential gardening efforts, were included in the development of research questions.

Participants were also asked to describe prior knowledge of heavy metal soil contaminants and their health effects, as well as whether they felt that they had adequate resources to learn more about the contaminants. When developing guiding questions, special consideration was given to previous research and best practices regarding using social science as methods for environmental health studies including DiCicco-Bloom & Crabtree, 2006; Hoover et al., 2015; Lobdell et al., 2005; and Scammell, 2010. A full list of the survey questions may be found in Appendix A.

Participants were not offered direct compensation for engaging in the study. However, they were encouraged to collect soil from their yards and gardens to bring to the Atlanta Science

Festival for free heavy metal contamination testing. Participants were also offered help with collecting these soil samples and transporting them to the Atlanta Science Festival for testing.

Funding for the project was obtained through the Emory Health and Exposome Research Center: Understanding Lifetime Exposures (HERCULES).

3.2. COMMUNITY EDUCATION & OUTREACH:

Given the outreach-based objectives of this study, each survey concluded with details on attending the Atlanta Science Festival. Each participant was given a flyer for soil testing at the Atlanta Science Festival, and each participant was also offered educational handouts provided by the CDC, the Agency for Toxic Substances and Disease Registry, and the EPA. Handouts provided information on safe practices for gardening in heavy metal contaminated soils, effective methods to protect oneself and one's children from lead poisoning, and ways to recognize lead poisoning and other possible negative health effects. All participants were provided with contact information for researchers, so they could ask follow-up questions, and all resources were also posted on the lab group's website at atlsoilsafety.com.

The study concluded with an outreach event at the Atlanta Science Festival, entitled "Getting Dirty: Exploring Soil on Atlanta Farms." The event included an urban farm tour focused on soil contamination and remediation education, as well as a booth where community soil samples were analyzed with X-ray Fluorescence. All participants received seeds and a garden startup kit for attending the event.

3.3. CODING:

A codebook was developed in the programming language R based on the survey questions and patterns from the initial responses. Questions with multiple-choice answers were grouped to have one categorical variable for analysis rather than multiple binary variables. Extraneous data, such as question type (multiple-choice, short answer, etc.) were eliminated. Results were transformed to include a complete data set including questions, question numbers, and all responses in a readable format. Upon review of final survey responses, the coding schema was adjusted accordingly. Only valid responses were included during the coding process.

Survey responses for categorical questions were sorted into categories by two researchers. The two researchers compared their groupings and determined any discrepancies before finalizing them. For questions asking whether participants are or are not aware of health effects/sources of exposure to heavy metal soil contaminants, follow-up questions were included to ensure that participants who answered “yes” were correct in their knowledge (Q22/Q23, Q24/Q25, and Q27/28 in Appendix A). Researchers checked these follow-up answers to ensure that participants who indicated “yes” but incorrectly described health effects/sources of exposure were not counted as aware and were instead grouped with those who originally answered “no.” Fisher’s exact test was then used to statistically analyze qualitative/categorical data.

Follow-up interview quotes best representing themes from the survey results are also included in the results section. These quotes exemplify the main patterns detected through coding the survey responses.

3.4. ETHICAL CONSIDERATIONS:

All study protocol, interview/focus group questions, and flyers were reviewed and subsequently approved by Emory University's Institutional Review Board (IRB). All participants were informed that they were not required to answer any survey questions that they did not wish to answer and had the right to withdraw at any time. Participants were also informed that their name would not appear in any report or publication from this project.

4. <u>RESULTS:</u>

4.1. DEMOGRAPHICS:

Fifty-one gardeners from across metro-Atlanta responded to the survey, and nine interviews were also conducted from among these respondents. Of the survey respondents, 60.9% were white/Caucasian, and 26.1% were black/African American (Table 1). 68.1% of respondents identified as female, and the median age group of participants was 35-44 years old. The average annual household incomes of respondents were varied. For example, 37.0% had an average annual household income of $0-$49,999, 28.3% had an average annual household income of $50,000-89,999, and 34.8% had an average annual household income of $90,000 or more (Table 2).

Home gardeners represented 45.1% of respondents, and community gardeners represented 23.5% of respondents. Additionally, 21.6% of respondents participated in both community gardens and home gardens (Table 3). Additional demographic data can be found in Appendix B and additional graphs of demographic data can be found in Appendix D.

Table 1 - Race:
Total question respondents: 51

Race	Number of Respondents	Percent of Respondents
American Indian or Alaskan Native	1	2.2%
Asian or Asian American	3	6.5%
Black or African American	12	26.1%
Hispanic or Latino	2	4.3%
White or Caucasian	28	60.9%
Preferred Not to Answer	5	N/A

Note: Percentages calculated with only valid responses (i.e. N/A responses not included in denominator)

Table 2 - Household Income:
Total question respondents: 51

Income Bracket	Number of Respondents	Percent of Respondents
$0 - $49,999	17	37%
$50,000 - $89,999	13	28.3%
$90,000 or more	16	34.8%
Preferred Not to Answer	5	N/A

Note: Percentages calculated with only valid responses (i.e. N/A responses not included in denominator)

Table 3 - Type of Garden:
Total question respondents: 51

Type of Garden	Number of Respondents	Percent of Respondents
Both	11	21.6%
Community garden	12	23.5%
Home garden	23	45.1%

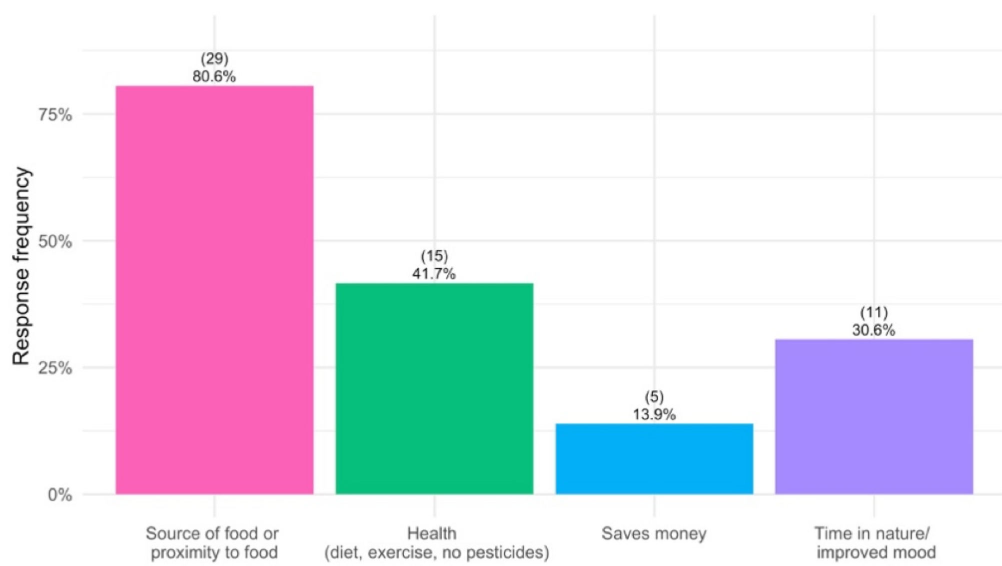
Total question respondents: 51

Note: 9.8% of respondents were not actively gardening, but had previously gardened or were preparing to start a garden.

4.2. PERCEIVED BENEFITS OF GARDENING:

Participants described four main benefits of participation in a home garden: proximity/ease of access to food, improved health (in terms of diet, exercise, and lack of pesticides), cost savings, and time spent in nature/improved mood (Figure 1). Respondents most frequently described proximity/ease of access to food with 80.6% of respondents mentioning it as a benefit. Additionally, 41.7% of participants cited improved health. Almost all respondents to the survey (93.1%) said that they did eat food grown in their gardens. Gardeners also described that they felt "in tune with nature" when engaging in home gardening and found gardening to be "therapeutic" and helpful in promoting "self-sufficiency."

Figure 1 – "If you participate in a home garden, what do you see as the benefits of participating in a home garden?" (Q12):
Total question respondents: 51



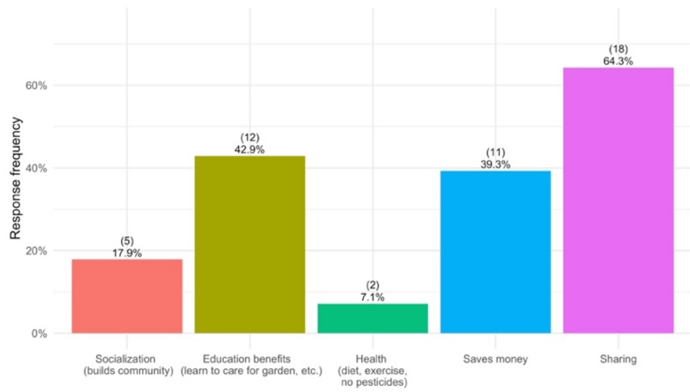
Respondents who engaged in community gardening activities described similar benefits. These benefits can be categorized into five main groups: community-building/socialization, education (i.e. on proper gardening techniques), improved health (in terms of diet, exercise, and lack of pesticides), cost savings, and sharing (Figure 2). Sharing was the most frequently described benefit of community gardening, and was listed among 64.3% of respondents who said they participated in a community garden. Participants described an improvement in their ability to share tools, land, infrastructure, and knowledge with others. As one participant described in a follow-up interview:

> *[Without a community garden], I just wouldn't have as much space. I live in a townhouse community, so I don't have my own yard. The community garden gives me space to garden that I wouldn't have access to otherwise… Also, just being able to interact with other gardeners, people who are interested in gardening and growing food the same as I am is nice. I appreciate that… I also like being able to help others access an ability to grow their own food.*

Educational benefits and cost savings were also frequently described. Of all respondents who participated in community gardens, 42.9% expressed satisfaction with the opportunity to educate themselves and their children on healthy gardening techniques, while 39.3% suggested that cost savings were a significant reason for their engagement with community gardens.

Figure 2 – "If you participate in a community garden, what do you see as the benefits of participating in a community garden?" (Q13):

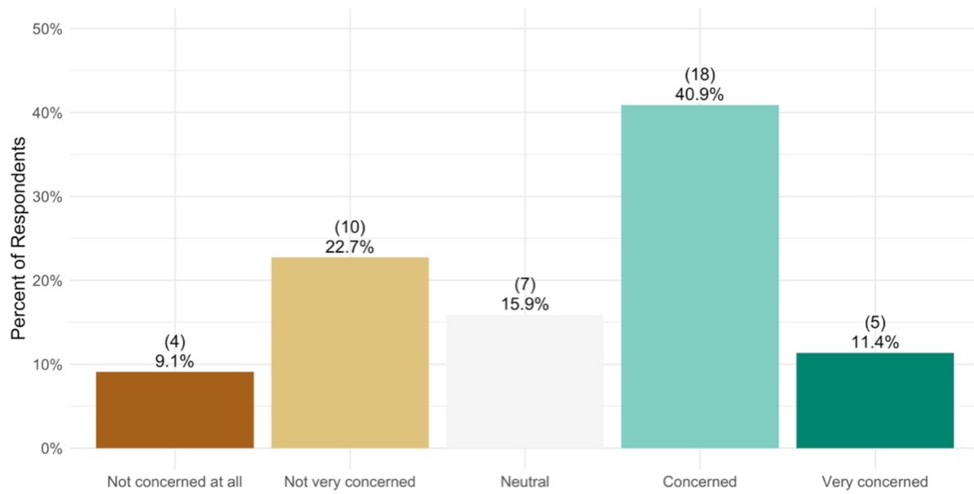
Total question respondents: 51



4.3. KNOWLEDGE AND CONCERN FOR HEAVY METAL SOIL CONTAMINANTS:

Most survey participants indicated that they were concerned about the potential health effects of heavy metal contaminants in soil, yet many were generally unconcerned with eating and/or working with produce in their gardens even if their soil had never been tested for contaminants before. Of all respondents to the survey, 11.4% said that they were "very concerned" about the health effects of heavy metals in soil and 40.9% said that they were "concerned." In contrast, only 31.8% said that they were "not concerned" or "not concerned at all" with these possible health effects (Figure 3). Despite this, 79.6% of participants indicated that they have not had any concerns for themselves or their families about eating and working with produce grown in their gardens.

Figure 3 – "How concerned are you about the potential health effects of heavy metal contaminants (lead, arsenic, chromium, etc.) in soil?" (Q26):
Total question respondents: 44



Only 18.2% of black/African American respondents were "very concerned" about the health effects of heavy metals in soil in comparison with 7.14% of white/Caucasian respondents (Table 4). Also, participants with children were slightly more likely to worry about heavy metals. Respondents with children were slightly more concerned with heavy metals, with 53.3% of respondents with children answering that they were "concerned" or "very concerned" with these contaminants. In comparison 50.0% of those without children said that they were "concerned" or "very concerned" about contaminants. However, the difference in this percentage between these two groups is narrow and was not statistically significant. Despite this narrow margin, participants with children were significantly more likely to "strongly agree" that heavy metals pose a risk to their health. More than half of those with children answered "strongly agree" when asked how much they feel heavy metals pose a threat to their health, while only 14.3% of those without children answered "strongly agree" to this same question (Table 5).

Table 4 – "How concerned are you about the potential health effects of heavy metal contaminants in soil?" (Q26):
Total question respondents: 44

	Not concerned at all	Not very concerned	Neutral	Concerned	Very concerned
Black or African American	0.0909	0.182	0.273	0.273	0.182
White or Caucasian	0.107	0.286	0.0714	0.464	0.0714

	Not concerned at all	Not very concerned	Neutral	Concerned	Very concerned
Both	0.0909	0.273	0.09091	0.364	0.182
Community garden	0.100	0.300	0.20	0.300	0.100
Home garden	0.0909	0.182	0.182	0.500	0.0456
Neither	0	0	0	0	1.00

Table 5 – "Do you think heavy metals in soil pose a significant risk to your health?" (Q29):
Total question respondents: 44

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Children	0	0.0667	0.167	0.233	0.533
No Children	0	0.143	0.286	0.429	0.143

Table 6 – "During your time living here, have you had any concerns for you and/or your family about eating and buying produce grown in your gardens?" (Q19):
Total question respondents: 44

	Yes, Have Been Concerned	No, Have Not Been Concerned
$0 - $49,999	0.294	0.706
$50,000 - $89,999	0.200	0.800
$90,000 or more	0.125	0.87

Individuals involved with a home garden were more likely to be worried about heavy metal contaminants than those involved with a community garden. Of all participants involved with a home garden, 54.5% were "concerned" or "very concerned" about heavy metal contaminants in comparison with 40.0% of those involved with a community garden (Table 4).

Participants involved with both a home and community garden were equally likely as those working only in a home garden to be “concerned” or “very concerned” (54.5%). About 9% of all respondents said that they were “not concerned at all” about heavy metal soil contaminants.

In general, average annual household income appeared to correlate with a decrease in concern with eating produce in the garden. For instance, 29.4% of respondents with average annual incomes of $0-$49,999 said that they had concerns about eating produce grown in their gardens, as opposed to 20.0% of respondents with average annual incomes of $50,000-$89,999 and 12.5% of respondents with average annual incomes of $90,000 or more (Table 6). Respondents with different household incomes varied in their knowledge of slag and ability to accurately describe characteristics and sources of slag (Table 7). However, it is important to note that this lack of correlation may be due to the small sample size.

Table 7 – “Do you know what slag is?” (Q22/Q23):
Total question respondents: 43

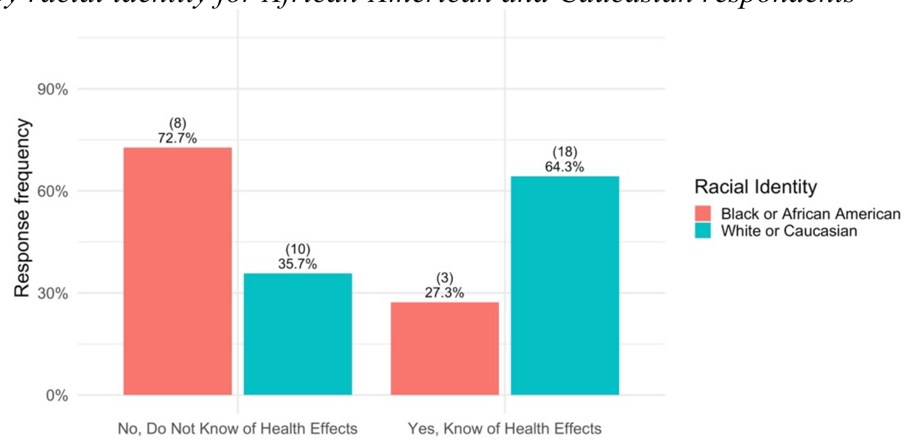
	Yes, Know What Slag Is	No, Do Not Know What Slag Is
Black or African American	0.273	0.727
White or Caucasian	0.444	0.556

	Yes, Know What Slag Is	No, Do Not Know What Slag Is
$0 - $49,999	0.375	0.625
$50,000 - $89,999	0.300	0.700
$90,000 or more	0.375	0.625

Figure 4 – "Do you know about any of the potential health effects of slag, lead, or arsenic in soil?" (Q24):

Total question respondents: 44

Knowledge by racial identity for African-American and Caucasian respondents



In terms of race, white/Caucasian respondents were very likely to indicate that they are aware of what slag is. 44.4% of White/Caucasian respondents could accurately describe slag as an industrial byproduct with high levels of heavy metals, in comparison with 27.3% of black/African American respondents (Table 7). Some participants (15.7%) answered that they were aware of what slag is, but could not accurately describe it as an industrial byproduct containing potentially harmful heavy metal contaminants.

The majority of participants were aware of and able to accurately describe the potential health effects of contaminants such as lead and arsenic, regardless of income levels. Overall, 54.6% of participants indicated that they were aware of these health effects. White/Caucasian participants were again more likely to state that they were aware of these health effects, with 64.3% of white/Caucasian participants answering that they were aware as opposed to 27.3% of black/African American participants answering that they were aware (Figure 4).

One survey respondent noted that she was concerned with the health effects of chemicals and pesticides much more so than soil contaminants. Another participant expressed concern that she, along with other gardeners in her community, lack appropriate knowledge to detect health effects of heavy metals. She also addressed the idea that community members may not want to have their soils tested for heavy metals or further their awareness of this topic:

> *My sense is that people [in my community garden] maybe suspect that there could possibly be some potential source of contamination. But they wouldn't even really know what those contaminants could even be. Like, what [contaminants] might be likely considering the location?... I certainly don't know how I would recognize the effects, you know, if [heavy metals] were having some effect on what I was growing or even my own health. I wouldn't know what [effects] to look for, and I would suspect that's probably true among the community as a whole... And it might be a bit of denial or avoidance [that causes this unawareness]. I actually recently had a conversation with a gardener about this, and she was like "You know, I don't know that I want to know. This [plot of land] is what I have to work with, so I have to just continue to do what I'm doing either way."*

Similarly, another participant described:

> *Nobody [in my garden] has ever asked about [heavy metal soil contaminants]. Nobody's ever questioned anything. We don't know if it's contaminated, we don't know what do about it, we don't ever think about it. But I think everyone would be interested [in learning more], especially because our garden is located on the site of a former city dump… But if I found out my soil was contaminated, I would of course want to remove all the contaminants from the soil. But I don't know who I would even go to for that.*

In many instances, participants who were more involved with gardening activities, such as those who participated in both home and community gardens, had increased knowledge of and expressed increased concern for health effects of heavy metal contaminants. In fact, 72.7% of respondents engaged with both community and home gardens stated that they were aware of potential health effects of slag, lead, and/or arsenic, in comparison to 40.0% of those involved only with community gardens and 54.6% of those involved only with home gardens (Table 8). One study participant was a leader in her gardening organization and had more than five years of experience with gardening. She said that because of her involved role in the garden organization, she was knowledgeable about the site history of her garden, which made her concerned about the potential for heavy metal soil contamination. For instance, she described the one garden used to be "an industrial dumping ground" and "sits right next to a busy road in the city."

Table 8 – "Do you know about any of the potential health effects of slag, lead, or arsenic in soil?" (Q24/Q25):

Total question respondents: 44

	Yes, Know of Health Effects	No, Do Not Know of Health Effects
Both	0.727	0.273
Community garden	0.400	0.600
Home garden	0.546	0.455

Table 9 – "Do you know about any of the potential sources of exposure to soil contaminants?" (Q27/Q28):

Total question respondents: 44

	Yes, Know of Sources	No, Do Not Know of Sources
Black or African American	0.364	0.636
White or Caucasian	0.500	0.500

	Yes, Know of Sources	No, Do Not Know of Sources
$0 - $49,999	0.529	0.471
$50,000 - $89,999	0.300	0.700
$90,000 or more	0.313	0.688

	Yes, Know of Sources	No, Do Not Know of Sources
Children	0.367	0.6333
No Children	0.500	0.5

	Yes, Know of Sources	No, Do Not Know of Sources
Both	0.546	0.455
Community garden	0.400	0.600
Home garden	0.364	0.636

4.4. SOURCES OF EXPOSURE TO CONTAMINANTS:

One participant said that he was highly concerned about "soil contamination living in an urban, post-industrial city and gardening next to an old home [built in 1950]." However, he added that the only strategy he was aware of to protect his health from these contaminants was to peel root vegetables before consumption. He stated:

> *Everyone in an urban environment signs up for added health hazards, from our soil, air, and water to vehicular accidents and high crime in the city. I believe the overall benefits of home and community gardening outweigh the possible soil contaminants issue. But I want to learn [to] make better decisions… There is a lot of information [regarding resources] online, but it is hard to know what sources to trust.*

This participant described that he was highly concerned with soil contamination, but did not know enough about sources of exposure to take preventative measures. This opinion and gap in knowledge seemed to be quite common among survey respondents as well. In fact, 59.1% of all individuals who answered the survey said that they did not know of any possible sources of exposure to soil contaminants. Among the respondents who said that they were aware of possible sources of exposure to soil contaminants, few were able to list more than one potential source.

Half of all white/Caucasian participants said that they were aware of sources of exposure, while only 36.4% of black/African American participants were aware (Table 9). An increase in average annual household income appeared to correlate with a decline in a participant's likelihood of knowing any sources of exposure (Table 9). This result may be due to higher income individuals believing that soil contamination is not a problem that personally affects them and thus, doing less individual research and education on the subject. However, additional studies are needed in order to study this possible reasoning and validate this conclusion.

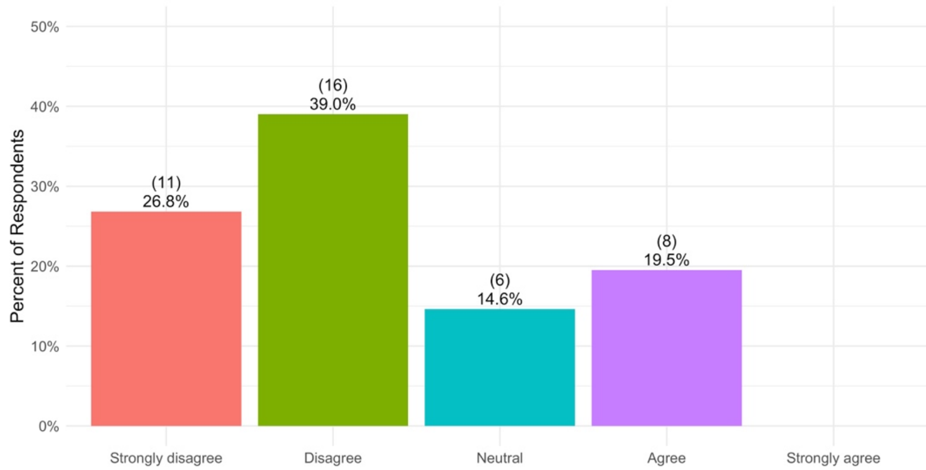
Half of the participants without children could list one or more sources of exposure, in comparison with only 36.7% of participants with children (Table 9). In addition, 54.6% of participants involved with both home and community gardens, 40.0% of participants involved with community gardens, and 36.4% of participants involved with home gardens were knowledgeable about one or more sources (Table 9).

4.5. ACCESS TO SOIL TESTING AND REMEDIATION RESOURCES:

A goal of the study was to identify communities in need of additional resources for soil remediation and to provide outreach tools and educational opportunities, such as the Atlanta Science Festival event. Overall, participants indicated that they were unaware of methods for remediating heavy metal soil contaminants and/or slag, regardless of income. When asked whether they were aware of ways to get rid of heavy metal soil contaminants and/or slag, 39.0% of all participants disagreed, and 26.8% strongly disagreed. Only 19.5% agreed, and 0 participants strongly agreed (Figure 5). Some participants suggested that they were aware that phytoremediation was a possibility, but they added that they did not know enough about specific seeds or methods needed to do this or where they could find more information. Other remediation techniques, such as raised beds, were infrequently described.

Figure 5 – "Do you know about ways to get rid of heavy metal soil contaminants and/or slag?" (Q33):

Total question respondents: 41



One survey respondent noted that she was unaware of any soil testing/remediation resources other than private soil testing businesses. During a follow-up interview, this participant suggested that if she did want her soil to be tested, it would be inconvenient to do so:

> *I've thought about having my soil tested by [an] extension office. It's not that I can't get there, but you know, it's just out of the way. It's inconvenient, and it's never on my mind. It's just out of my normal range of doing things... The easiest thing would probably be if I could take a soil sample and just send it somewhere- if I could just stick [the sample] in a vile and put it in the mail and the results could come back to me. So I think for anybody, it's just the time and inconvenience factor [that prevents us from having our soil tested.]*

Alongside convenience, another participant described transportation as a limiting factor to having her soil tested. In a follow-up interview, a third participant stated that in the context of her garden, she did not have the budget necessary to remediate heavy metals in her soil. Instead, when the presence of heavy metals was detected in her soils, she and other garden participants designated the site as a "non-edible space" where they discontinued growing produce. She added that she was glad these non-edible spaces were not large because she was unsure how she would remediate the soil if it had taken up a larger portion of the garden space. She stated:

> *"Remediation would not only take money, but also time, and I don't have that kind of time… We [members of the community garden] have actually had our soil tested before, and instead of removing the heavy metals, we would just designate that site as a non-edible space… Luckily it wasn't really a big portion of the garden."*

The same participant added that written and/or printed educational materials should be distributed to gardeners. She acknowledged that though in-person classes and hands-on workshops would be more informative, this would be too difficult for her gardening community to coordinate among members and to schedule. Other participants also cited the importance of physical and digital references for gardeners, as well as an expert whom they could contact to ask specific questions about heavy metal soil contaminants. Additional data from the survey's findings can be found in Appendix C and Appendix D.

5. <u>DISCUSSION:</u>

5.1. SIGNIFICANCE OF RESULTS AND HYPOTHESES:

A combination of surveys and interviews with gardeners and farmers in metro-Atlanta provided an opportunity to better understand the risks they perceived in relation to heavy metal soil contaminants as well as general public awareness related to remediation resources. Almost all study participants easily described multiple benefits of working with gardens in urban areas, especially regarding improved access to healthy food sources. However, knowledge and concern for possible heavy metal soil contaminants was much more varied and not as easily or frequently described by participants.

Many participants seemed to express some concerns with the possibility of heavy metal soil contaminants, especially when describing the adverse health effects they were aware of. Despite this, nearly 80.0% of participants were unconcerned with eating and buying produce grown in urban gardens. Interviews revealed that many respondents had never had their soil tested, even those who lived in former industrial sites. For some, this was a result of never thinking that soil testing was necessary, and for others, this was a matter of convenience. Given these findings, it is possible that while participants are aware of the health effects of heavy metal soil contaminants, they do not think that the amount of contamination is high enough to pose a significant risk to their personal health. Even though they have not had their soil samples tested to prove that it is safe, they do not believe the level of contamination would have a significant impact on them. Improved access to soil testing through cheaper and closer facilities and/or programs may help to better connect gardeners to the quality and safety levels of their soil on a more individualized and personal level.

It is also worthwhile to recognize that the majority of participants were unaware of possible sources of exposure to soil contaminants. Local extension offices and community organizations should consider educating gardeners about sources of exposure. It would also be beneficial to inform gardeners of personal actions that they can take to reduce exposure, such as thoroughly washing produce, keeping garden plots far away from industrial sites and busy roads, and leaving garden tools outside of the home. Such actions can reduce harmful exposures, regardless of awareness of whether contaminants exist in high concentrations.

These findings closely support previous studies conducted. For instance, Kim et al., (2014) identified low levels of concern and knowledge about heavy metal contaminants and a lack of confidence in the ability to reduce exposure and remediate soil. Both this study and Kim et al. (2014) found that lead was the most frequently described contaminant because respondents infrequently mentioned other trace metals, such as arsenic. In both studies, the lack of confidence in listing potential soil remediation practices was particularly noticeable. Some interviewees in this study mentioned that they refrain from growing produce in a certain area if they find out the area is contaminated, and Kim et al. (2014) likewise found that 50.0% of respondents view this as an adequate form of remediation. Both studies found that urban gardeners generally lacked knowledge regarding other remedial practices, such as phytoremediation. Unlike Kim et al. (2014), this study found that respondents generally preferred indirect education tools, such as handouts and online information hubs, rather than interactive, in-person outreach. Additionally, the findings of this study closely resemble those of Harms et al. (2013), who found that urban gardeners had minimal confidence in their knowledge of remedial resources.

Particular attention should be paid to differences in findings between racial groups through this study. Some risk assessments of different racial groups were negligible. For instance, black/African American respondents were only minimally more concerned about the health effects of heavy metals in soil. The difference in responses between black/African American respondents and white/Caucasian respondents in this area is not large enough to draw a valid conclusion. However, in some cases, differences in survey results from various ethnic groups were more noticeable. White/Caucasian participants were much more likely to answer that they are aware of the health effects of heavy metals. This information is important in order to determine which racial groups and communities in metro-Atlanta should be targeted more for intervention strategies. Based on these results, black/African American communities may be more likely to benefit significantly from additional outreach efforts, such as classes, events, and educational materials regarding the health effects of soil contaminants and remediation efforts.

Community gardeners, more so than home gardeners, may also greatly benefit from additional outreach and education efforts. Differences in awareness between community and home gardeners regarding sources of exposure and remediation methods were minimal. However, home gardeners appeared to have a significantly greater understanding of the adverse health effects of heavy metal soil contaminants. This outcome was surprising, especially because community gardeners frequently cited education and the sharing of knowledge and information as perceived benefits of working and/or volunteering in community gardens. This difference in knowledge could potentially be attributed to home gardeners engaging in more independent research on the subject rather than relying on the knowledge of their neighbors and community members.

In many instances, average annual household income did not seem to be a factor that strongly correlated with the knowledge of participants regarding soil contaminants and remediation. Price also did not appear to be a critical factor affecting one's ability to seek soil testing or remediation. However, during interviews, participants brought up other factors that may be important to address in order to improve awareness of this topic. For example, one participant addressed the fact that many gardeners in her community are reluctant to seek soil testing because they would not be able to remediate their soil or find other, uncontaminated plots of land to garden in. This suggests that more focus should be placed on educating individuals about how they can easily access remediation resources. If individuals understand that remediation efforts are feasible options for them, they may be more inclined to test their soil for contaminants.

This study disproved many initial hypotheses. Individuals with higher average household incomes did not necessarily have more knowledge of the health effects of heavy metal soil contaminants or of possible resources to remediate heavy metal soil contaminants. Individuals participating in community gardens, were also not necessarily more aware of these topics, and in many cases, individuals participating in home gardens were actually more aware. Additionally, individuals with lower average annual household incomes did often eat produce from the gardens often, but not necessarily any more than individuals with higher average annual household incomes. In fact, the majority of participants across all incomes ate produce from their gardens.

These results suggest a potential need to better communicate and educate health exposures, soil testing, and remediation methods related to heavy metal soil contaminants. Citizen science programs such as VegeSafe have provided free soil metal screening to communities, allowing researchers to gather data on heavy metal soil exposures, which they then report to community members. The program also advises community members on solutions if soils contain high levels of heavy metals (Rouillon et al., 2017). Tools such as this one may benefit urban gardeners.

The event "Getting Dirty: Exploring Soil on Atlanta Farms" at the Atlanta Science Festival proved to be a successful outreach event that attracted 250 residents of metro-Atlanta, as well as individuals interested in beginning gardening. This outreach event, which provided a combination of both hands-on activities such as soil testing, as well as more informal opportunities to hand out educational flyers, generally received positive feedback from attendees and community members. This study provides information that supports the need for further outreach efforts and also suggests which communities should be targeted and which methods should be used in order to most effectively improve awareness of heavy metal soil contaminants, especially as the prevalence of urban agriculture is expected to increase. The study also indicates that resources to soil testing and remediation should be better publicized and made more accessible to urban gardeners.

5.2. CONCERNS AND LIMITATIONS:

Recruiting a large group of participants for the study was a challenge. As a result, the sample size for the study was relatively small. This may limit the extent to which these results can be generalized to other urban areas and to residents of Atlanta who did not participate in the study. Because of the relatively small sample size, it is difficult to infer statistical significance. While this study can help to provide a broader understanding of community gardeners' awareness of heavy metal soil contaminants, future studies should seek to gather a larger sample size.

The participants included in the study may have also skewed the data. Researchers attempted to contact a wide and diverse range of respondents through the American Community Gardening Association's database and by collecting surveys at the Atlanta Science Festival event, which was open and advertised to all Atlanta-area gardeners. However, many of the gardeners may still have been associated with HWG, which could have limited the ability to accurately generalize results to communities and residents outside of this organization with confidence. Because most respondents were either black/African American or white/Caucasian, it is especially difficult to compare data across races. For this reason, we were unable to draw valid conclusions about American Indian/Alaskan Native, Asian/Asian American, and Hispanic, Latino participants. Instead, it was more significant to compare data across demographic factors that were more varied, such as average annual household income and type of garden participated in.

A third possible limitation of this study is non-response error. Because gardeners provided with the survey were not required to complete the survey, some potential participants may have chosen not to participate in the study due to time constraints or disinterest. Some potential respondents may have been discouraged from completing the entirety of the survey due to its length. As a result, the results of the data may be skewed. Future studies should further minimize this error by attempting to recruit a larger proportion of respondents from the sample of potential participants in order to reduce any skew in the data due to non-response error.

5.3. OPPORTUNITIES FOR FUTURE STUDIES:

There are many opportunities for future studies related to measuring community awareness of heavy metal soil contaminants and determining best practices to improve awareness in communities in the future. Additional studies should be conducted in order to corroborate the findings of this study. Such studies could use other social science methods, such as focus groups, to continue to analyze community awareness of soil contaminants through a different format than surveys and follow-up interviews. A greater number of studies regarding this topic will help to validate the data by reaching a broader sample size and a wider variety of participants.

Comparing information gained through this study with information on actual levels of soil contamination in Atlanta communities is also an important opportunity for future research. This study did not gather information on whether respondents had had their soil tested for heavy metal contaminants before and what the results of these tests were, if they had previously submitted samples for testing. Researchers could distribute surveys to fill this gap in information, and they could also sample soils in metro-Atlanta gardens to determine if any areas with low levels of knowledge regarding soil contaminants had high levels of contamination. This research could be important in order to more effectively target outreach efforts to vulnerable populations.

Because this study's scope was limited to the metro-Atlanta area, it is also important that follow-up studies be conducted outside of Atlanta. Other urban areas may have different levels of heavy metal soil contaminants and thus, may have greater community awareness of these contaminants. Additionally, local city interventions may differ between cities. Future research should be conducted in previously unstudied areas in order to determine whether the results of this study are specific only to Atlanta. Additionally, it would be interesting to study related topics, such as what gardeners feel are cutoffs for how much they would be willing to pay to have their soil tested or how far they would travel to have their soil tested.

Because urban agriculture has many benefits and is growing more popular, it is important to better understand how to improve the safety of gardeners. Additional studies can help to better understand in which areas gardeners lack knowledge concerning heavy metals. This information can then be used, especially in conjunction with outreach efforts, to inform community organizations on how to better educate gardeners, policy-makers on how they can make soil testing more accessible, and individuals on how they can continue to garden safely. Such social science studies are especially significant in order to target the most vulnerable populations and efficiently improve the safety and well-being of urban gardeners.

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7. APPENDIX A – SURVEY QUESTIONS:

Directions: Please circle your answer and write your explanation if necessary.

1. *Consent Form Signature*

2. What is your race? Please circle all that apply.
   a. White or Caucasian
   b. Black or African-American
   c. Hispanic or Latino
   d. American Indian or Alaskan Native
   e. Asian or Asian America
   f. Native Hawaiian or other Pacific Islander
   g. Other (please specify): __________________

3. What is your annual household income (how much total combined money did all members of your household earn in 2018)?
   a. $0 – $9,999
   b. $10,000 – $29,999
   c. $30,000 – $49,999
   d. $50,000 – $69,999
   e. $70,000 – $89,999
   f. $90,000 – or more

4. What is your age?
   a. 18-24
   b. 25-34
   c. 35-44
   d. 45-54
   e. 55-64
   f. 65+

5. What is your gender?
   a. Male
   b. Female
   c. Other

6. Which neighborhood do you live in? ____

7. How long have you lived in your neighborhood?
   a. Less than 1 year
   b. 1-2 years
   c. 3-5 years
   d. 6-7 years
   e. 8-10 years
   f. Longer than 10 years

8. Do you have any children?
   a. Yes
   b. No

9. If you answered yes to #8, how old are your children? If you answered no, please write N/A.
   ____

10. How many people live in your household? ____

11. What type of garden do you participate in? Please select all that apply:
    a. Home garden
    b. Community garden (please specify which one): ________________

12. If you participate in a home garden, what do you see as the benefits of participating in a home garden?
    ____
    ____

13. If you participate in a community garden, what do you see as the benefits of participating in a community garden?
    ____
    ____

14. In what capacity do you participate in your garden(s) (i.e. tend to the garden, help with weed clean-up, eat produce, etc.)?
    ____
    ____

15. How many days a week do you participate in your garden(s)?
    a. 1 day a week
    b. 2-3 days a week
    c. 4-5 days a week
    d. 6-7 days a week

16. What is the primary purpose of the food you grow in your gardens? Please select all that apply.
    a. Personal consumption
    b. Family consumption
    c. To sell to others
    d. Other: ________________

17. Do you eat produce grown in your garden(s)?
    a. Yes
    b. No

18. If you answered yes to #17, please describe. For example, which foods do you eat? How often? How much? Do you ever sell the produce to other community members or feed it to your family?
    ____
    ____

19. During your time living here, have you had any concerns (for you and/or your family) about eating and buying produce grown in your gardens?
    a. Yes
    b. No

20. If you answered yes to #19, please describe:
    ____
    ____

21. During your time living here, have you had any concerns (for you and/or your family) about the health effects related to how long or much you are exposed to soil? Please describe:
    ____
    ____

22. Do you know what slag is?

a. Yes
b. No

23. If you answered yes to #22, please describe:
____
____

24. Do you know about any of the potential health effects of slag, lead, or arsenic in soil?
    a. Yes
    b. No

25. If you answered yes to #24, please explain:
____
____

26. How concerned are you about the potential health effects of heavy metal contaminants (lead, arsenic, chromium, etc.) in soil?
    a. Very concerned (I think about it every day)
    b. Concerned (I don't think about it every once in a while when I'm gardening)
    c. Neutral
    d. Not very concerned (I know about the health effects, but am not worried about them)
    e. Not concerned at all (I have never thought about the health effects and/or am unaware of them)

27. Do you know about any of potential sources of exposure to soil contaminants?
    a. Yes
    b. No

28. If you answered yes to #27, please explain:
____
____

29. Do you think heavy metals in soil pose a significant risk to your health?
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

30. Please explain your answer to #29:
____
____

31. Do you know what resources you have to learn more about heavy metal contaminants in soil?
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

32. Please explain your answer to #31 and if applicable, list any resources you are aware of:
____
____

33. Do you know about ways to get rid of heavy metal soil contaminants and/or slag?
    a. Strongly agree

   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

34. Please explain your answer to #33, and if applicable, list any methods you are aware of:
____
____

35. Have you ever wanted to get rid of heavy metal soil contaminants and/or slag, but did not have the resources and/or funding to do so?
   a. Yes
   b. No

36. Please explain your answer to #35:
____
____

37. How likely would you be to take action to remove heavy metal soil contaminants from soil if you were made aware of them?
   a. Very likely
   b. Likely
   c. Neutral
   d. Not likely
   e. Not likely at all

38. Would you be available and interested in an additional, in-person interview to further discuss this topic? The interview would last about 20-30 minutes. It would allow you to provide more detailed information about your answers to this survey and would provide a chance to learn more about heavy metal contaminants and resources you can access to learn more. If so, please provide your name and best method of contact below. (This information will ONLY be used to contact you for an in-person interview.)
Name: __________________________
Email: __________________________
Phone: __________________________

8. APPENDIX B – DEMOGRAPHIC TABLES AND GRAPHS:

Table 10 - Gender:

Total question respondents: 51

Income Bracket	Percent of Respondents
Male	31.9%
Female	68.1%

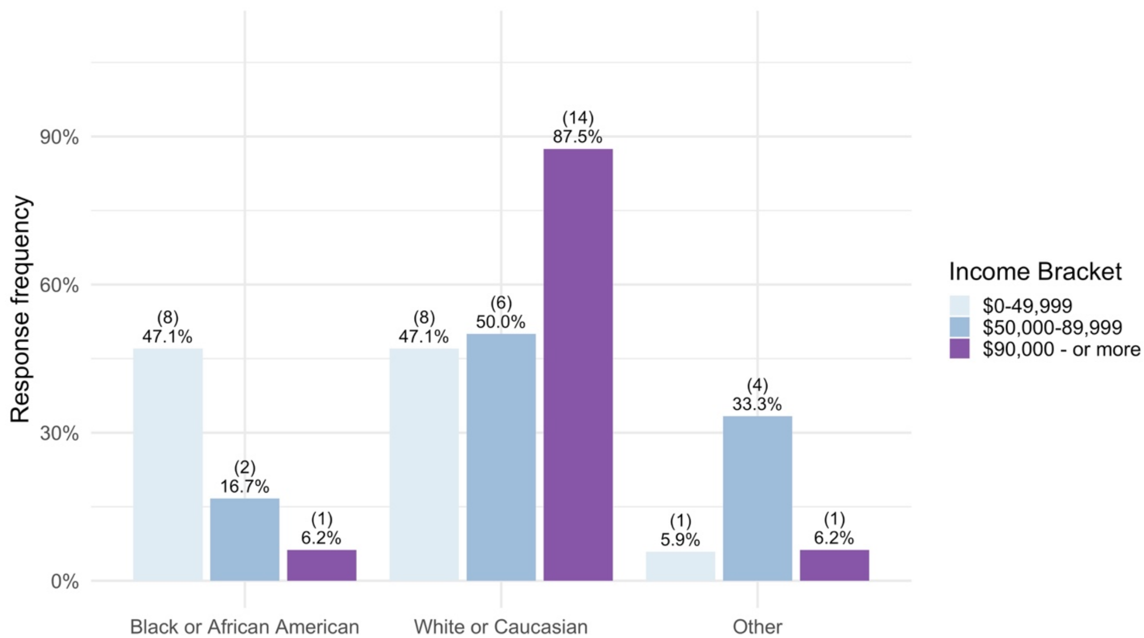
Table 11 - Children:

Total question respondents: 51

Children	Number of Respondents	Percent of Respondents
Children	31	66.0%
No Children	16	34.0%
Preferred Not to Answer	4	N/A

Note: Percentages calculated with only valid responses (i.e. N/A responses not included in denominator)

Figure 6 – Income vs. Race:
Total question respondents: 51



9. APPENDIX C – ANALYTICAL TABLES:

Table 12 – "Do you eat produce grown in your garden" (Q17):
Total question respondents: 44

	Yes, Eat Produce	No, Do Not Eat Produce
Black or African American	0.909	0.0909
White or Caucasian	0.929	0.0714

	Yes, Eat Produce	No, Do Not Eat Produce
$0 - $49,999	0.941	0.0588
$50,000 - $89,999	0.900	0.100
$90,000 or more	0.938	0.0625

Table 13 – "During your time living here, have you had any concerns for you and/or your family about eating and buying produce grown in your gardens?" (Q19):
Total question respondents: 44

	Yes, Have Been Concerned	No, Have Not Been Concerned
Black or African American	0.182	0.818
White or Caucasian	0.250	0.750

	Yes, Have Been Concerned	No, Have Not Been Concerned
Children	0.133	0.867
No Children	0.357	0.643

	Yes, Have Been Concerned	No, Have Not Been Concerned
Both	0.182	0.818
Community garden	0.200	0.800
Home garden	0.227	0.773

Table 14 – "Do you know about any of the potential health effects of slag, lead, or arsenic in soil?" (Q24/Q25):
Total question respondents: 44

	Yes, Do Know of Health Effects	No, Do Not Know of Health Effects
Black or African American	0.273	0.727
White or Caucasian	0.643	0.357

	Yes, Know of Health Effects	No, Do Not Know of Health Effects
$0 - $49,999	0.471	0.529
$50,000 -$89,999	0.400	0.600
$90,000 or more	0.500	0.500

	Yes, Know of Health Effects	No, Do Not Know of Health Effects
Children	0.533	0.467
No Children	0.571	0.429

Table 15 – "How concerned are you about the potential health effects of heavy metal contaminants in soil?" (Q26):
Total question respondents: 44

	Not concerned at all	Not very concerned	Neutral	Concerned	Very concerned
$0 - $49,999	0.0588	0.177	0.118	0.412	0.235
$50,000 - $89,999	0.200	0.200	0.200	0.400	0
$90,000 or more	0.0625	0.250	0.188	0.438	0.0625

	Not concerned at all	Not very concerned	Neutral	Concerned	Very concerned
Children	0.0667	0.233	0.167	0.433	0.100
No Children	0.143	0.214	0.143	0.357	0.143

Table 16 – "Do you think heavy metals in soil pose a significant risk to your health?" (Q29):

Total question respondents: 44

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Black or African American	0	0.0909	0.0909	0.273	0.546
White or Caucasian	0	0.107	0.250	0.357	0.286

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
$0 - $49,999	0	0.118	0.177	0.294	0.412
$50,000 - $89,999	0	0.200	0.300	0.200	0.300
$90,000 or more	0	0.2	0.188	0.313	0.500

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Both	0	0.182	0.182	0.455	0.182
Community garden	0	0	0.400	0.300	0.300
Home garden	0	0.0909	0.136	0.227	0.546

Table 17 – "Do you know what resources you have to learn more about heavy metal contaminants in soil?" (Q31):

Total question respondents: 41

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Black or African American	0	0.182	0.546	0.182	0.0909
White or Caucasian	0	0.240	0.360	0.360	0.0400

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
$0 - $49,999	0	0.177	0.471	0.294	0.0589
$50,000 - $89,999	0	0.300	0.400	0.200	0.100
$90,000 or more	0	0.231	0.462	0.308	0

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Both	0	0.182	0.455	0.364	0
Community garden	0	0.375	0.375	0.250	0
Home garden	0	0.191	0.476	0.238	0.0952

Table 18 – "Do you know about ways to get rid of heavy metal soil contaminants and/or slag?" (Q33):
Total question respondents: 41

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Black or African American	0.273	0.455	0.182	0.0909	0
White or Caucasian	0.240	0.320	0.160	0.280	0

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
$0 - $49,999	0.177	0.353	0. 177	0.294	0
$50,000 - $89,999	0.100	0.600	0.200	0.100	0
$90,000 or more	0.462	0.308	0.0769	0.154	0

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Both	0.273	0.273	0.182	0.273	0
Community garden	0.125	0.375	0.250	0.250	0
Home garden	0.286	0.476	0.0952	0.143	0

Table 19 – "Have you ever wanted to get rid of heavy metal soil contaminants and/or slag, but did not have the resources and/or funding to do so?" (Q35):
Total question respondents: 40

	Yes, Have Lacked Funding	No, Have Not Lacked Funding
Black or African American	0.300	0.700
White or Caucasian	0.320	0.680

	Yes, Have Lacked Funding	No, Have Not Lacked Funding
$0 - $49,999	0.563	0.438
$50,000 - $89,999	0.100	0.900
$90,000 or more	0.0769	0.923

	Yes, Have Lacked Funding	No, Have Not Lacked Funding
Both	0.455	0.546
Community garden	0.286	0.714
Home garden	0.191	0.810

Table 20 – "How likely would you be to take action to remove heavy metal soil contaminants from soil if you were made aware of them?" (Q37):

Total question respondents: 41

	Not very likely	Unlikely	Neutral	Likely	Very likely
Black or African American	0	0	0.273	0.0909	0.636
White or Caucasian	0	0	0.120	0.560	0.320

	Not very likely	Unlikely	Neutral	Likely	Very likely
$0 - $49,999	0	0	0.177	0.353	0.471
$50,000 - $89,999	0	0	0.1	0.500	0.400
$90,000 or more	0	0	0.231	0.308	0.462

	Not very likely	Unlikely	Neutral	Likely	Very likely
Children	0	0	0.185	0.333	0.482
No Children	0	0	0.143	0.429	0.429

	Not very likely	Unlikely	Neutral	Likely	Very likely
Both	0	0	0	0.4555	0.546
Community garden	0	0	0.250	0.375	0.375
Home garden	0	0	0.238	0.333	0.429

8. APPENDIX D – ANALYTICAL GRAPHS:

All figures are graphed as Response Frequency (y-axis) vs. Answer to Survey Question (x-axis).

Figure 7 – "What is your annual household income (how much total combined money did all members of your household earn in 2018)?" (Q3):
Total question respondents: 51

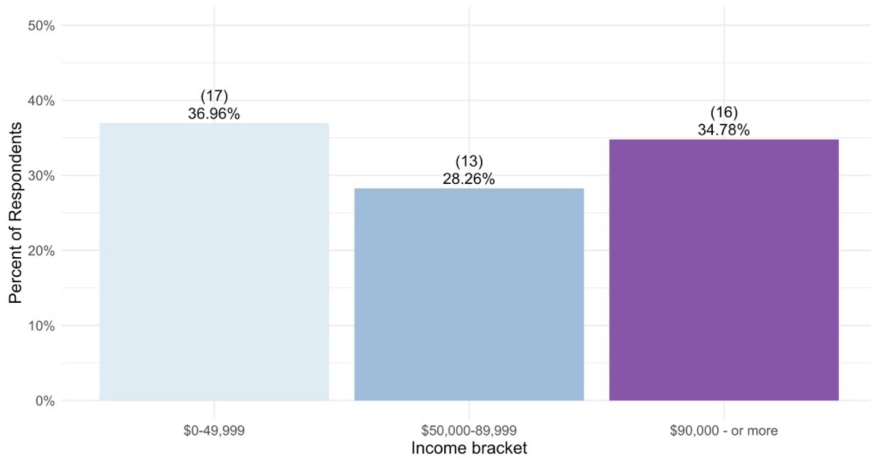


Figure 8 – "What is your age?" (Q4):
Total question respondents: 51

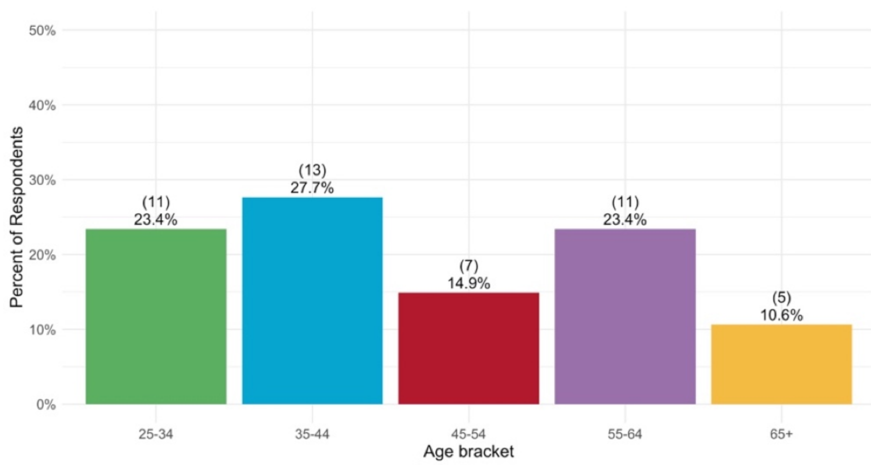


Figure 9 – "Do you think heavy metals in soil pose a significant risk to your health?" (Q29):
Total question respondents: 44

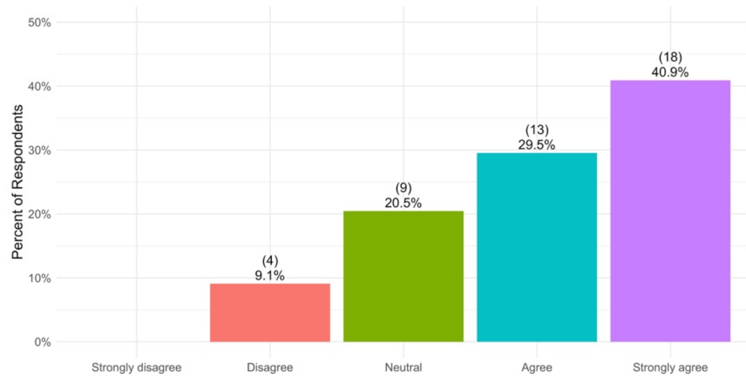


Figure 10 – "Do you know what resources you have to learn more about heavy metal contaminants in soil?" (Q31):
Total question respondents: 41

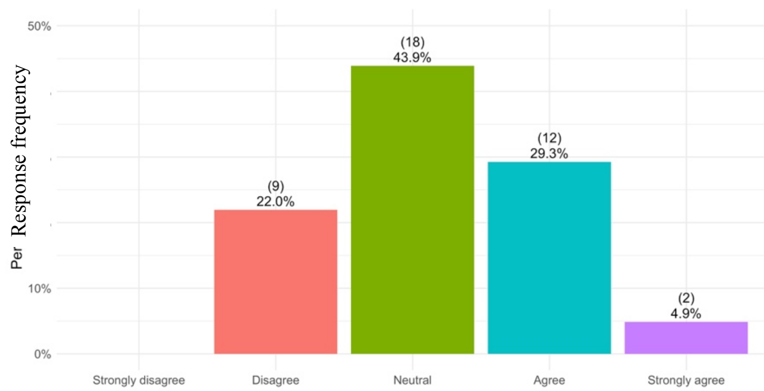


Figure 11 – "Have you ever wanted to get rid of heavy metal soil contaminants and/or slag, but did not have the resources and/or funding to do so?" (Q35):
Total question respondents: 40

Knowledge by income bracket

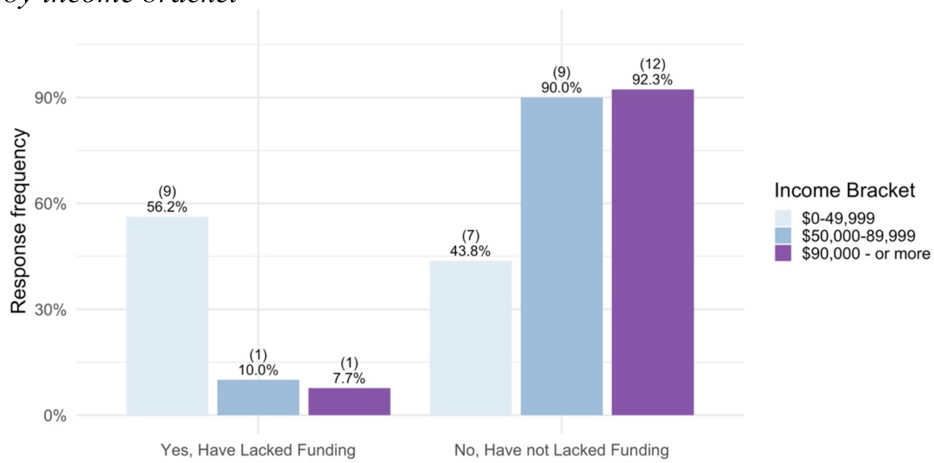


Figure 12 – "How likely would you be to take action to remove heavy metal soil contaminants from soil if you were made aware of them?" (Q37):
Total question respondents: 41

Knowledge by racial identity