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Research Article

Understanding the knowledge of Mogpog residents about heavy metal pollution due to mining and its associated health risk

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Abstract

The municipality of Mogpog in the Philippines was one of the severely hit areas during the 1993 mining disaster in the province of Marinduque. After three (3) decades, the aftermath of the disaster still lingers in the municipality and even in the whole province. This study was conducted to assess the relationship between the social demographics of the residents of Mogpog and their knowledge about heavy metal (HM) pollution and its associated health risks. A cross-sectional survey was conducted among the 314 residents of Mogpog. Six (6) social demographics were considered, such as age, sex, marital status, highest education attainment, monthly household income, and whether the respondents were government employees or not. The results of the binomial logistic regression analysis showed that the social demographics affecting the respondents' knowledge about HM pollution were marital status and monthly household income (significant at the 0.05 level). Married individuals may have larger and more diverse social networks, which could expose them to a wider range of information, including environmental issues. On the other hand, those with lower incomes may have limited access to formal education or information resources, which could result in lower environmental awareness. The results underscore the need for specific interventions and educational initiatives to enhance the understanding of the adverse health impacts associated with HM pollution among residents in Mogpog.

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Introduction

Heavy metals (HMs) are elements that occur naturally and are typically present in rocks, soils, and sediments. In the pre-industrial era, the levels of HMs in the environment were primarily regulated by natural processes, including leaching from underground rocks and sediments. Nevertheless, in recent decades, human activities have led to a substantial and continuous rise in HM concentrations in the environment globally, contributing to a widespread environmental pollution issue (Bawa-Allah, 2023). Due to its abundant mineral deposits, the Philippines held the second position after Indonesia in 2000 concerning potential minerals and resources. Consequently, there are numerous mining operations in the country. Such human activities have been proven to disrupt natural ecosystems, leading to issues like the total depletion of natural vegetation, soil acidification, and degradation of organic and microbial soil characteristics. Additionally, these activities result in heavy metal contamination in both terrestrial and nearby aquatic ecosystems (Marjorie et al., 2018; Mendoza et al., 2023; Senoro et al., 2023). Marinduque, an island province in the Philippines, was acknowledged for containing one of the nation's significant copper reserves. Consequently, copper

mining activities commenced in Marinduque in 1969. While the mining industry was initiated in the province in 1964, an unfortunate incident occurred on December 6, 1993, when the Maguilaguila siltation dam, serving as a tailing pond, collapsed. This event led to the discharge of mine tailings into the Mogpog River (Nolos et al., 2022). Three decades later, the repercussions of the mining disaster continue to impact the province. The contamination, primarily caused by HMs, persists in various environmental mediums like surface water, groundwater, soil, sediments, and agricultural yields (Mariano, 2019; Gigantone et al., 2020; Agarin et al., 2021; Monjardin et al., 2022; Senoro et al., 2022; Monjardin et al., 2023). As a result, health concerns persist among the communities affected by the disaster. Additionally, the abandoned mine sites present dangers to the community, especially during heavy rainfall or earthquakes, due to their structural vulnerabilities.

Understanding the knowledge of the residents of Mogpog about HM pollution and its potential health risks is indispensable. Reams et al. (2013) investigated emergency planning within households and the behaviors aimed at reducing exposure to air pollution among Louisiana residents. Their study revealed that those who stay informed about air quality forecasts, frequently checking them, demonstrated a greater tendency to modify their behavior to minimize exposure to environmental risks. Furthermore, the analysis suggested that individuals possessing elevated levels of knowledge and concern regarding environmental hazards, coupled with recent encounters with disruptive events, were more inclined to take proactive measures to enhance their safety. Furthermore, studies on risk perception broaden the foundational notion of risk, which involves the likelihood of an unfavorable event resulting in losses. These studies encompass people's values, knowledge, concern, and awareness regarding such events. The significance of these studies for risk management lies primarily in enhancing the efficiency, effectiveness, and acceptance of policies or decisions (Pidgeon, 1998). Factors related to social demographics, including age, gender, education, income, employment, political ideology, and more, have been identified as having substantial impacts on individuals' perspectives, awareness, attitudes, and concerns regarding specific environmental issues and risks (Dogaru et al., 2009). Hence, this study was conducted with the following objectives: (1) characterize the social demographics of the residents in Mogpog; (2) determine the level of knowledge of the residents about heavy metal pollution; and (3) assess the influence of the residents' social demographics on their knowledge of heavy metal pollution.

Materials and Methods

Study area

Mogpog is one of the six (6) municipalities in the province of Marinduque (Figure 1), which has 37 barangays. The geographical coordinates of the municipality are 13.47528° N and 121.86° E.

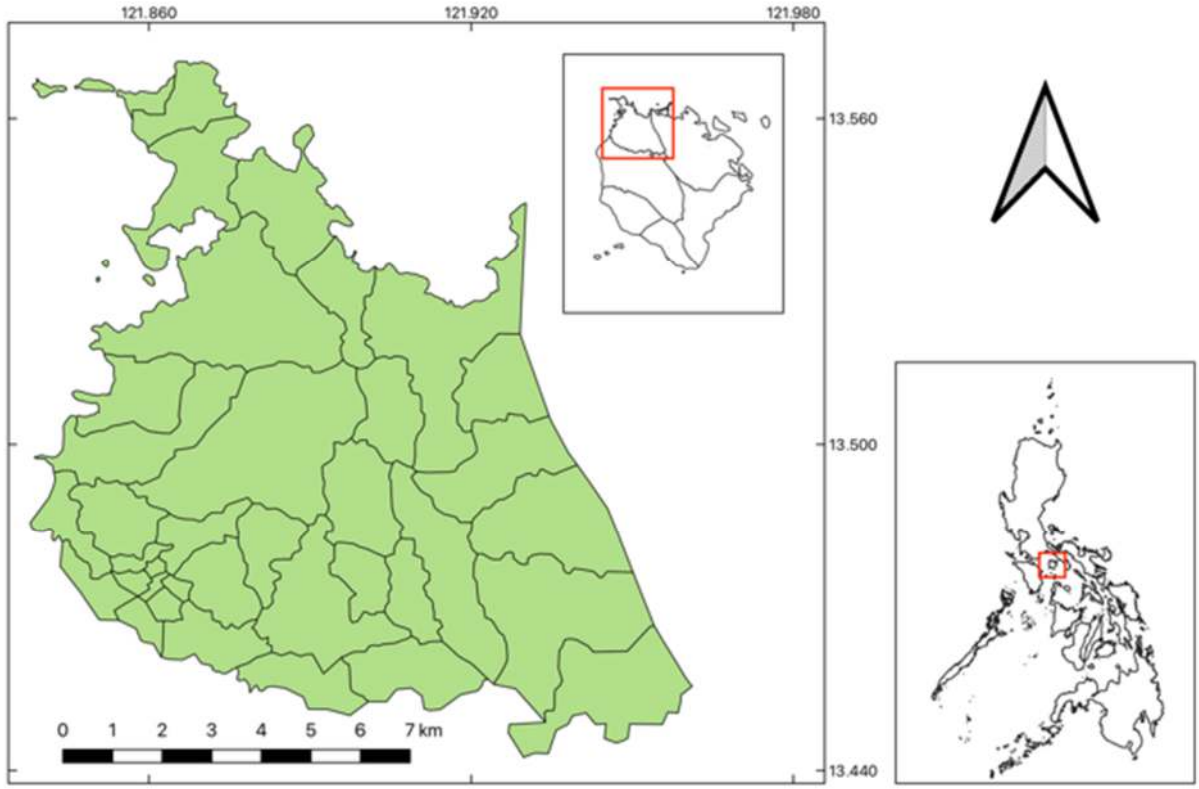

Figure 1. Map of the study area.

The municipality is bounded on the north by Sayao Bay, on the south by Boac Municipality, on the east by Sta. Cruz Municipality, and on the west by Tablas Strait (Municipality of Mogpog, 2019).

Data gathering

A cross-sectional survey was conducted among the residents of Mogpog from November 2022-March 2023. The inclusion criteria for the respondents were (a) being residents of Mogpog, (b) being 18 years of age or older, and (c) freely consenting to participate in the survey. Convenience sampling was employed in the study (Sedgwick, 2013). The sample size was calculated using Cochran's formula, which is ideal for calculating sample sizes from a large population (Al-Rasheedi, 2023). In 2020, the total population of 18-year-olds and older in the municipality was 22,426 (Philippine Statistics Authority, 2010). By utilizing a 5% margin of error and a confidence level of 90%, the obtained sample size was 268. However, the collected survey responses were greater than the computed sample size, which was 314.

A pre-tested structured questionnaire along with an informed consent form were used in the survey. The survey questionnaire was constructed based on the literature on heavy metal pollution and its associated health effects (Oves et al., 2012; Jaishankar et al., 2014). The reliability by internal consistency of the survey questionnaire was assessed using Kuder-Richardson (KR20). The obtained KR20 was 0.72, which is considered acceptable (Gómez-Rodríguez et al., 2020). Prior to the survey, coordination with the concerned Local Government Units (LGUs) was made, and the objectives of the study were explained to the respondents.

The survey consisted of two (2) parts. The first part assessed the social demographics of the respondents, including sex, age (years), highest educational attainment, marital status, monthly household income (Philippine Peso - PhP), and whether they are government employees or not. The second part, on the other hand, consisted of nineteen (19) items to assess the respondents' knowledge in relation to HM pollution. The level of knowledge was considered "good" if the score is equal or greater than 50% while "poor" if the score is less than 50% (Mamady, 2016).

Data analysis

Descriptive statistics of the respondents' demographic characteristics and the results of KAPs were provided using Microsoft Excel Version 16.52. Binomial logistic regression using Python was utilized to evaluate the influence of social demographics on the respondent's knowledge in relation to HM pollution (Penman, 2022). Six (6) predictors were considered in the regression analysis, including sex, age (years), highest educational attainment, marital status, monthly household income (PhP), and government employee or not (Zhang et al., 2020).

Results

Social demographics of the respondents

The social demographics of the respondents are shown in Figure 2.

In terms of age distribution, 15% of the respondents fell within the 18-24 years age group, 21% were in the 25-34 years age group, 25% belonged to the 35-44 years age group, 19% were within the 45-54 years age group, and 20% were aged 55 years and above (Figure 2a). It was also recorded that 64% of the respondents were male, while 36% were female (Figure 2b).

In terms of marital status, 38% of the respondents were single, 50% were married, 10% were widowed, and 2% were separated (Figure 2c). For the highest educational attainment, 20% were elementary graduates, 51% were high school graduates, 9% were vocational graduates, and 20% were college graduates (Figure 2d).

In terms of monthly income, 88% of the respondents earn less than PhP10,000 monthly, 11% have monthly income of PhP10,001-PhP50,000, and 1% earn PhP50,001-PhP1000,000 monthly (Figure 2e). Lastly, 77% of the respondents were government employees, while 23% were non-government employees (Figure 2f).

Level of knowledge

Table 1 shows the level of knowledge of the respondents about heavy metal (HM) pollution and its associated health risks. About 82% of the respondents already knew the term heavy metals. Similarly, about 94% and 98% of the respondents believed that HMs were harmful to the environment and health, respectively. About 65% knew the possible sources of high levels of HMs in the environment. Similarly, the majority of the respondents believed that HMs may be introduced to the human body through the following pathways: ingestion of foods contaminated with HMs (95%), incidental ingestion (95%), inhalation (96%), and dermal absorption (90%). On the other hand, about 89% and 97% of the respondents believed that excessive use of pesticides and abandoned mines could be sources of HM contamination.

In terms of the associated health risks that can be acquired from regular exposure to high levels of heavy metals, the majority of the respondents believed that it could potentially cause diarrhea (93%), skin diseases (97%), headaches (88%), lung cancer (96%), liver problems (92%), heart problems (86%), liver problems (88%), heart problems (88%), kidney problems (85%), and cognitive issues (78%).

Five transition metals, including arsenic, cadmium, hexavalent chromium, beryllium, and nickel, are recognized as human carcinogens under specific forms or routes of exposure (Goyer, 2004). Remarkably, about 96% of the respondents have a good level of knowledge about HM pollution and its associated health risks.

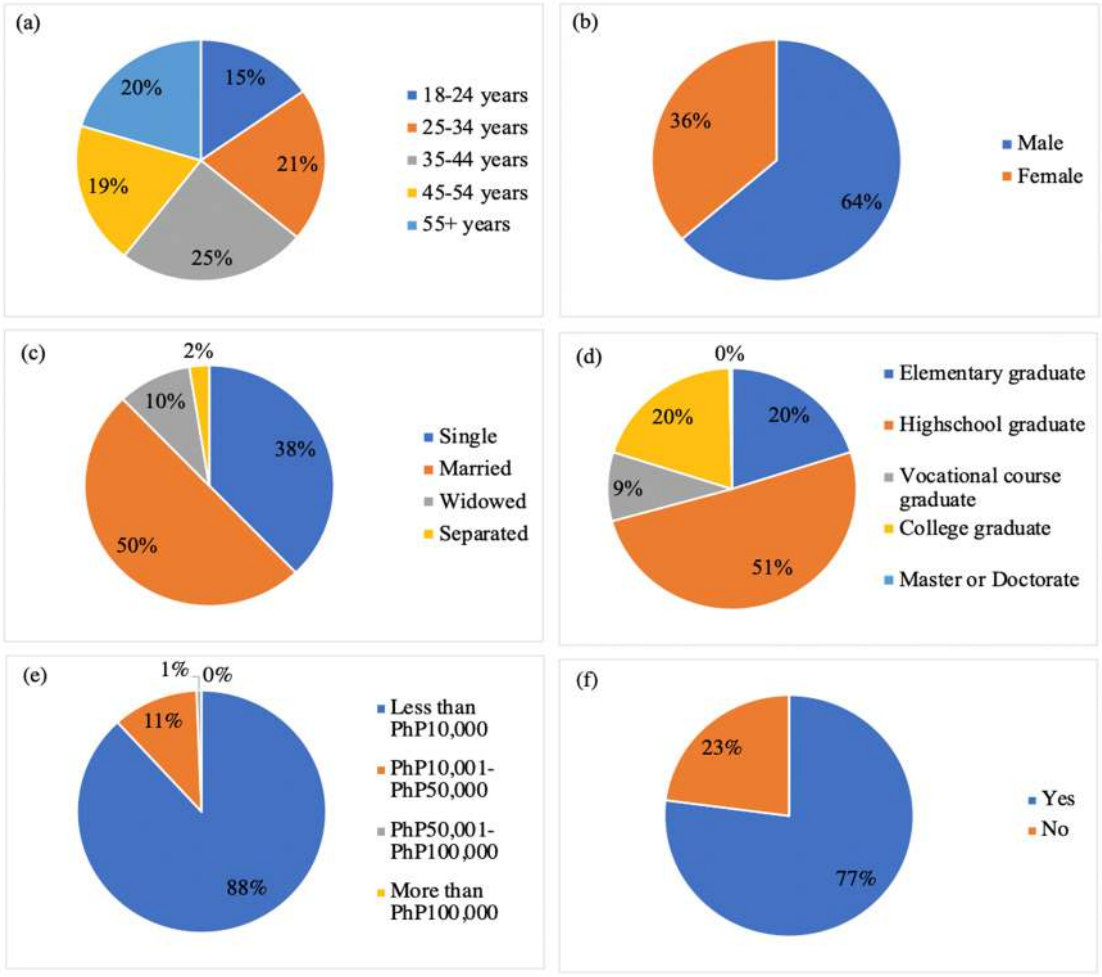

Figure 2. Social demographics of the respondents (n=314): (a) age, (b) sex, (c) marital status, (d) highest educational attainment, (e) monthly household income, and (f) government employee.

Table 1. Level of knowledge of the respondents about heavy metal pollution and associated health risk (n=314).

Questions	No	Yes
1. Have you ever heard the term "heavy metals"?	57	257
2. Is a high level of heavy metals dangerous to the environment?	20	294
3. Is a high level of heavy metals hazardous to health?	6	308
4. Do you know the possible sources of high levels of heavy metals in the environment?	109	205
5. Can heavy metals enter the body through the consumption of contaminated vegetables, fruits, and others?	16	298
6. Can heavy metals enter the body through incidental ingestion of contaminated soil or dust?	16	298
7. Can heavy metals enter the body through inhalation of contaminated dust?	12	302
8. Can heavy metals in the soil enter the body through the skin?	31	283
9. Can the excessive use of pesticides and insecticides be a source of heavy metal contamination?	33	281
10. Can mining or abandoned mines be a source of heavy metal contamination?	9	305
11. Regular exposure to high levels of heavy metals can potentially cause diarrhea.	22	292
12. Regular exposure to high levels of heavy metals can potentially cause skin diseases.	8	306
13. Regular exposure to high levels of heavy metals can potentially lead to anemia.	37	277
14. Regular exposure to high levels of heavy metals can potentially cause headaches.	11	303
15. Regular exposure to high levels of heavy metals can potentially cause lung cancer.	25	289
16. Regular exposure to high levels of heavy metals can potentially cause liver problems.	44	270
17. Regular exposure to high levels of heavy metals can potentially cause heart problems.	39	275
18. Regular exposure to high levels of heavy metals can potentially cause kidney problems.	46	268
19. Regular exposure to high levels of heavy metals can potentially cause cognitive issues.	83	294

Binomial logistic regression

The result of the binomial logistic regression between the social demographics and the knowledge of the respondents about HM pollution is shown in Table 2. It was found that marital status (p-value=0.00) and monthly household income (p-value=0.02) were significant predictors of the respondents' knowledge about HM pollution.

Table 2. Binomial logistic regression of the respondents' social demographics and knowledge.

	coef	std err	z	P>|z|	0.025	0.975
Const	3.99	1.05	3.80	0.00	1.93	6.01
Age	0.01	0.02	0.91	0.36	-0.02	0.05
Sex	0.38	0.49	0.77	0.44	-0.58	1.33
Marital Status	-1.01	0.29	-3.47	0.00*	-1.59	-0.44
Highest Educational Attainment	0.37	0.27	1.40	0.16	-0.15	0.89
Monthly household income	-1.44	0.60	-2.41	0.02*	-2.61	-0.27
Government official	1.50	0.80	1.88	0.06	-0.07	3.07

*significant at 0.05 level.

Discussion

The majority of respondents demonstrated a good understanding of heavy metal (HM) pollution, which can be attributed to their direct experiences with the aftermath of mining activities. Sana et al. (2017) investigated the knowledge and perceptions of health and environmental risks among artisanal miners in Burkina Faso. The findings revealed that respondents possessed a high level of knowledge regarding the environmental and health impacts of artisanal gold mining. This heightened awareness was attributed to their firsthand experiences, including a history of activities associated with related diseases. It is a well-known fact that the majority of HMs contribute to environmental and atmospheric pollution, posing potential lethality to humans. These metals can attain heightened toxicity when interacting with various environmental elements, including water, soil, and air. Residents downstream of a Bolivian mining site were assessed for heavy metal concentrations in their blood. The findings indicated elevated frequencies of hypertension and hematuria, conditions likely attributed to exposure to mine tailings (Farag et al., 2015). Further, humans can be exposed to heavy metals through various pathways. Ingestion of contaminated food and water, where plants, animals, and seafood accumulate metals, is a significant route (Nolos et al., 2022; Mendoza et al., 2023; Senoro et al., 2023). Inhalation of airborne particles, such as dust or industrial fumes, poses exposure risks, particularly in occupational settings and areas with high pollution levels. Dermal contact with contaminated soil, dust, or surfaces can lead to absorption through the skin, with certain occupations or recreational activities contributing to this exposure route (Li et al., 2017).

In this study, two (2) social demographics were found to be significant predictors of the respondents' knowledge, namely marital status and monthly household income. Married individuals may have larger and more diverse social networks, which could expose them to a wider range of information, including environmental issues. The sharing of information within a family unit might contribute to higher knowledge levels about HM pollution (Waite, 1995). Similarly, being in a marital relationship might influence a sense of responsibility for the well-being of the family. This sense of responsibility could extend to environmental concerns, prompting married individuals to seek and retain information about potential health risks related to HM pollution (Thomas et al., 2017). Marital status may also influence the way individuals consume media. Married couples might be more likely to discuss and engage with news, documentaries, or educational content related to environmental issues like HM pollution, contributing to higher knowledge levels (Hung and Bayrak, 2019). Exploring the specific knowledge gaps within different marital status groups could provide insights in Mogpog that need more attention in educational programs. For the relationship between the respondents' monthly household income and knowledge, it can be considered that those respondents with lower incomes may have limited access to formal education or information resources, which could result in lower environmental awareness (Strieder-Philippssen et al., 2017). Similarly, they may prioritize meeting basic needs such as food, shelter, and healthcare, leaving less time and resources for staying informed about environmental issues (Caswell and Yaktine, 2013). Higher-income individuals may have better access to information through various channels, such as the internet. Lower-income individuals might face barriers to accessing these information sources (Lazar and Davenport, 2018). Understanding this relationship can guide efforts to bridge the knowledge gap. Targeted educational programs, community outreach initiatives, and policy interventions may be needed to ensure that information about HM pollution and its health risks is accessible to individuals across different income levels in the municipality. It also highlights the importance of considering socioeconomic factors in environmental awareness campaigns to promote inclusivity and equitable distribution of knowledge (Nolos et al., 2023; Suprapto et al., 2023).

Conclusion

This study assessed the relationship between the social demographics and knowledge about heavy metal pollution of the residents of the municipality Mogpog, Marinduque, Philippines. Results of the social demographics showed that the majority of the respondents belonged to the 35-44 years age group, were male, were married, were high school graduates, earning a monthly household income of less than PhP10,000, and were government employees. Remarkably, about 96% of the respondents have a good level of knowledge about HM pollution and its associated health risks. The results of the binomial logistic regression revealed that marital status and monthly household income were the significant predictors of the respondents' knowledge about HM pollution and its associated health risks. This is a pioneering study in the municipality, and the findings can be used by relevant agencies for targeted information dissemination and further awareness about the adverse health impacts of HM pollution.

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