

Family Practices To Address Mercury Contamination Or Poisoning

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Abstract

Artisanal gold mining in the lower San Jorge River basin in Córdoba has generated severe environmental and health impacts due to the use of mercury. Objective: To analyze family practices to address mercury contamination or poisoning. A qualitative, ethnographic, and descriptive approach was adopted to explore families' experiences and perceptions. Methodology: Fieldwork included direct observations, interviews, focus groups, and analysis of field diaries, following the methods of Hammersley and Atkinson. The research considers the meanings attributed by communities to their daily practices and how these are influenced by social, cultural, and economic factors. Results: Families employ traditional knowledge and cultural adaptations to reduce mercury exposure. These strategies include the use of informal preventive practices and the incorporation of local beliefs into their risk management. Social dynamics that facilitate or constrain the adoption of preventive measures were identified. Conclusions: The findings underscore the importance of integrating local knowledge into the design of public health strategies to mitigate mercury exposure. These interventions must be culturally sensitive, sustainable, and focused on strengthening communities' capacity to manage environmental risks.

Keywords: Meanings, practices, mitigation, risk, family, mercury (DeCS Criteria)

INTRODUCTION

Mineral extraction is a crucial economic activity that supports a variety of global and regional industries, contributing significantly to the income of producing countries (MEC, 2019). In particular, gold mining is one of the most relevant activities, not only due to its economic importance but also because it generates employment and investment (Amstrong & Menon, 2001) and (Eisler, 2003). In Colombia, gold plays a fundamental role in the country's economic development, being one of the main sources of income for many of its departments (DNP, 2011). However, mining practices, especially those carried out using artisanal methods, present significant challenges, mainly due to the use of mercury in the mineral extraction process (Villalobos, 2019). Amalgamation, a widely used technique to separate gold from the earth, uses mercury, a heavy metal that has serious implications for human health and the environment (WHO, 2021).

Mercury is a highly toxic element with bioaccumulative and biomagnifying properties, meaning it accumulates in living organisms and increases along the food chain (WHO, 2021). These factors make its presence in ecosystems particularly dangerous, affecting both humans and local wildlife. In regions such as Ayapel, located in the department of Córdoba, mercury contamination from mining activities has generated serious environmental and social impacts, including the degradation of fishery resources and the direct exposure of local communities to dangerous levels of this metal (OCHA, 2016) and (Gracia et al., 2009). The release of mercury vapors during the heating of amalgams under inadequate conditions contributes to the dispersion of the contaminant, which is deposited in water sources, transforming into methylmercury, an even more toxic form and capable of entering the food chain through fish, the main economic resource of the region (Vargas-Licona & Marrugo-Negrete, 2019).

This process has exacerbated public health problems in the area, as mercury poisoning is associated with severe neurological effects, including damage to the central nervous system and negative effects on reproductive health, primarily affecting the most vulnerable populations, such as children and pregnant women (Palma-Parra et al., 2019) and (Poulin et al., 2019). In particular, the Mojana region, where

Ayapel is located, is especially susceptible to the impacts of mining due to its proximity to areas of high mining activity in northeastern Antioquia, which generates large volumes of contaminated runoff. Furthermore, informal and illegal mining further aggravates the situation, as it contributes to the lack of control over mercury emissions, intensifying environmental and social risks for nearby communities (Rocha-Román et al., 2018) and (Mosquera et al., 2018).

In this context, it is urgent to implement effective environmental monitoring strategies, identify the main sources of contamination, and promote actions to mitigate mercury exposure. This study focuses on the case of Ayapel, exploring both the magnitude of the problem and its repercussions on human health and the environment, with the aim of proposing interventions that contribute to improving the quality of life of its inhabitants and preserving the region's natural resources (Casas et al., 2021) and (CVS, 2014).

The San Jorge River region, characterized by its vast network of water bodies, such as canals, ravines, and streams, faces serious challenges derived from artisanal and small-scale mining, especially with regard to mercury emissions (Gracia et al., 2009). This problem has prompted a series of legislative efforts and strategies in Colombia to control mercury contamination, whose impact on the health of nearby communities is serious, in addition to deteriorating the natural environment (MA, 2021). Among the main initiatives are the control of mercury exposure, early care for those affected, and the strengthening of the institutions responsible for addressing this problem, along with the promotion of research projects on environmental and public health impacts (Casas et al., 2021).

Research on the effects of mercury has focused more on measuring its presence in food, water, and fish, leaving a significant gap in epidemiological studies that comprehensively link exposure with impacts on human health (Muñoz-Vallejo et al., 2012) and (Vargas-Licona & Marrugo-Negrete, 2021). This gap is particularly critical considering that the adverse effects of mercury, such as neurological problems, insomnia, memory loss, nervousness, and concentration difficulties, primarily affect children and adolescents (Muñoz-Vallejo et al., 2012). Oxidative stress caused by mercury exposure generates neurotoxic effects, severely altering the central nervous system, which requires urgent attention in affected communities (Vargas-Licona & Marrugo-Negrete, 2021).

Despite evidence of health risks, significant challenges remain in providing care to affected communities. These include limitations in case diagnosis and follow-up, as well as a lack of adequate technical infrastructure in public health laboratories (Macías et al., 2024). Furthermore, there is a lack of coordination between the different sectors responsible for implementing policies to reduce mercury exposure, and a significant lack of awareness among local communities about the risks associated with this element (Taylor & Bodgan, 2022). The solutions proposed so far, such as the relocation of affected residents, have not considered the cultural and social roots of these communities, which has generated resistance and a lack of acceptance of the measures adopted (Arciniega, 2025).

Given this scenario, it is essential to understand the practices, meanings, and perceptions of families exposed to mercury in order to design mitigation strategies that are effective and culturally appropriate (Macías et al., 2024). Qualitative research, with an interpretive ethnographic approach, is key to exploring the social dynamics, behaviors, and perceptions that communities have regarding mercury risk (Taylor & Bodgan, 2022). This approach not only facilitates the interpretation of families' responses to risks but also contributes to the formulation of public policies that are tailored to local realities, promoting resilience and community empowerment (Arciniega, 2025) and (World Bank, 2021).

In this sense, the research seeks to identify the strategies that families have developed or can develop to mitigate mercury exposure. These strategies, based on local knowledge and the cultural dynamics of the region, constitute a crucial starting point for avoiding health damage, reducing vulnerability, and building resilient communities capable of facing the challenges posed by environmental pollution (Macías et al., 2024).

The study of the practices and meanings developed by families in the municipality of Ayapel, in the lower basin of the San Jorge River, is essential to understanding how communities cope with the risks associated with mercury exposure from mining activities. 16 This approach not only allows for identifying the social, economic, and cultural characteristics of families in high-risk areas, but also facilitates the design of public policies that integrate health programs with local capacities, promoting more sustainable and equitable development (WHO, 2021).

From a public health perspective, the relevance of this study lies in offering a comprehensive view of the mercury problem, addressing not only the health effects but also the everyday practices that communities

implement to mitigate the impact of mercury on their environment despite a lack of information and support (WHO, 2021) and (MSPS, 2019). According to the Córdoba Public Health Impact Program, this study complies with the strategic guidelines that prioritize environmental health and risk management in the region, especially in a context marked by territorial violence and the constant threat of environmental deterioration (Vesgas, 2018).

The qualitative methodology adopted, with an interpretive ethnographic approach, allows us to access the families' subjectivity and understand how they perceive and respond to the risks they face (Guber, 2001) and (Anandón, 2007). This approach not only facilitates the interpretation of their behaviors and attitudes but also contributes to the formulation of public policies based on local knowledge and the validation of the experiences of the region's inhabitants (Lévano, 2007) and (Nolla-Cao, 1997). Through this process, we seek to strengthen the communities' adaptive capacities, creating resilient spaces that allow them not only to confront current risks but also to reduce future exposure to mercury.

This research becomes a crucial tool for the development of mercury risk mitigation strategies, providing valuable data that can be used at both the local and national levels to improve the living conditions of affected communities and protect their natural resources.

Problem Question: ¿What are the family practices for dealing with mercury contamination or poisoning? **General Objective:** Analyze family practices for dealing with mercury contamination or poisoning.

METHODOLOGY

The research follows an interpretive approach, in which the researcher assumes the role of observer of individuals' practices, behaviors, and narratives within their social context. According to Pérez Teodoro, the researcher not only observes human interactions but also seeks to understand the meanings and interpretations that actors give to their lived reality, considering both their daily practices and the contexts in which they operate (Pérez, 2022). This paradigm allows for a deep understanding of subjectivity and the meanings individuals attribute to their world.

Research Approach

The research approach is qualitative and descriptive, which facilitates exploring and understanding the experiences, perceptions, and practices of families in the lower San Jorge River basin. The objective is to capture the specific nature of the phenomena without reducing them to pre-established categories. Following the ideas of Taylor and Bodgan (2022), and drawing on the work of Hammersley and Atkinson (2022), this approach avoids value judgments and observes events from the perspective of the "natives," that is, the communities themselves. The purpose is to understand the meanings that people give to their experiences, especially in relation to risk mitigation due to exposure to mercury from mining.

The methodological design is based on an ethnographic approach, which involves a deep immersion in the culture of the community studied (Guber, 2001). Through direct observations, interviews, and field diary records, the aim is to understand how community members value and manage the risks associated with mining. Ethnography allows for a comprehensive capture of risk mitigation practices, considering families' narratives and daily interactions and acknowledging local knowledge and beliefs. This approach offers a detailed and respectful reconstruction of the meanings that local actors assign to their situation (Anandón, 2007).

Detailed and respectful construction of the meanings attributed by local actors

The methodology of this study focuses on interpreting the meanings that local actors attribute to their experiences and practices in relation to the risk of mercury exposure in the lower San Jorge River basin, Ayapel municipality. This ethnographic approach allows for a deep and contextualized understanding of how families perceive and manage the risks associated with mercury contamination (Lévano, 2022). Ethnography is a key tool, as it not only observes the subjects' daily actions but also the meanings these actions hold for them within their cultural context. According to Guber (Guber, 2001), ethnography goes beyond simple observation, interpreting what the researcher observes and hears, which enriches the analysis of the social phenomenon. This approach focuses not only on everyday practices but also on the beliefs, values, and strategies that guide the behavior of community members, revealing how they construct their social reality in relation to mercury risk (Nolla-Cao, 1997).

The methodology recognizes the importance of multicausality in the health-disease process, especially in relation to the effects of mercury exposure [26]. Identifying the social and cultural relationships that influence the adoption of preventive strategies and risk perception is considered essential. Following

Madeleine Leininger's theory of Cultural Care, it is understood that knowledge about the cultural structure of families can be decisive for implementing health interventions that respect and adapt to their realities (Pérez-Pimentel, 2009).

Contextualization of the study

The study is part of a micro-ethnography, as it focuses on a specific social institution: the family. Through detailed observation and interpretation of the daily practices of families in the lower San Jorge River basin, we seek to understand how they adopt strategies to mitigate mercury exposure and how these practices are influenced by their social, economic, political, and cultural contexts. This approach allows for deep immersion and detailed analysis within a defined space, facilitating the interpretation of local practices (Quecendo & Garrido, 2003).

The methodology also highlights the importance of periodic visits to the territory, which not only allow for data collection but also for establishing relationships of trust with the community (Blanco & Castro, 2007). The temporal flexibility of the visits is essential, as it depends on access conditions and the availability of participants. This ensures that local actors define, to the extent possible, the pace and conditions of the study. This flexibility allows for a respectful construction of knowledge, where the voices of participants are actively heard (Otzen & Manterola, 2017).

Thematic Approach to Observation

The research focuses on family members' meanings and experiences regarding mercury exposure. It seeks to identify preventive actions taken, the beliefs that underlie them, and the strategies used to protect themselves, all within the framework of their risk perception. This approach requires continuous and adaptive analysis, adjusting to emerging narratives and practices during data collection (Mejía-Navarrete, 2014).

Community Immersion and Contact Procedure

Initial Reconnaissance: Key actors are identified, such as community leaders and single mothers, who will facilitate access to families and an understanding of the social context of the lower San Jorge River basin. The characteristics of the environment are also studied, including neighborhood layout and the organizational structure of homes (Mason, 2021).

Gradual Immersion: Through periodic visits and contact with families, the purpose of explaining the purpose of the study and encouraging participation is sought. Data collection will be gradual, allowing for constant adaptation to field conditions and participant availability (Güber, 2004).

Selection and Participation Criteria

Participants will be selected based on representativeness criteria, considering the families' demographic characteristics and their willingness to participate voluntarily (Hernández et al., 2010). We will work with families residing in the lower San Jorge River basin who have not experienced recent migration changes, thereby capturing a consistent view of local practices. It is also crucial that participants be involved in activities related to mercury exposure (Valles, 2003). The study recognizes that external factors, such as relocation, illness, insecurity, or climate change, could disrupt participation. To mitigate these risks, we will enlist the support of local leaders, who will facilitate ongoing contact with participants and help organize interviews and focus groups when they are available (Taylor & Bogdan, 1994).

The methodology employed seeks a deep and respectful understanding of the meanings families attribute to their experiences related to mercury risk. Through constant immersion in their social and cultural reality, we ensure that the data collected accurately reflect the perceptions and practices of local actors in their unique context (Schettini & Cortazzo, 2021).

Sampling

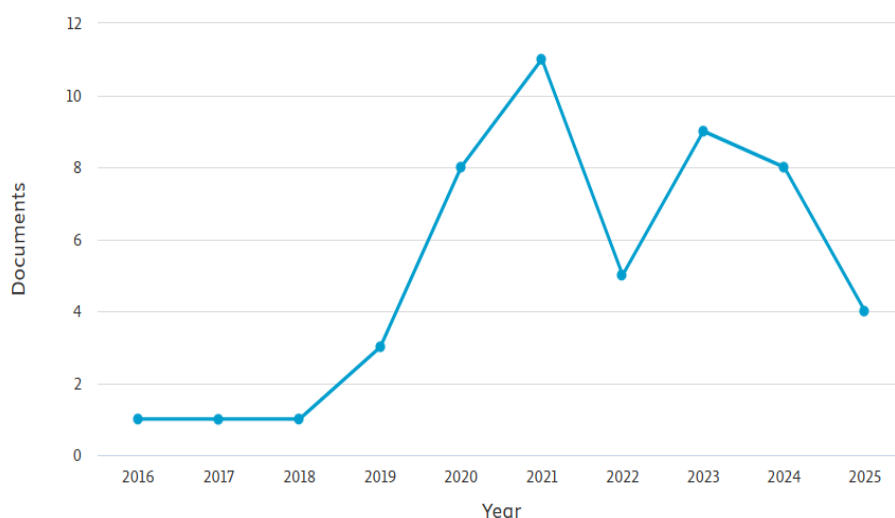
The sampling in this study follows a flexible and progressive approach, adapted to the qualitative context [43]. It begins with convenience sampling, where participants are selected voluntarily, without prior inclusion criteria. This type of sampling is suitable for conducting an initial approach to the population, allowing for the inclusion of all those willing to participate (Mejía-Navarrete, 2014). As the research progresses, it moves to avalanche or snowball sampling, where the initial participants help identify new subjects through recommendations (Mason, 2021).

As the fieldwork progresses, the methodology evolves toward theoretical or judgmental sampling, in which family groups representative of the study population are specifically selected, ensuring greater representativeness in the selected cases (Mejía-Navarrete, 2014). This allows for a clear definition of the

universities and institutions across the country are intensifying their scientific work to alert government agencies (Chart 1).

Chart 1.

Evolution of the issue over the last decade.

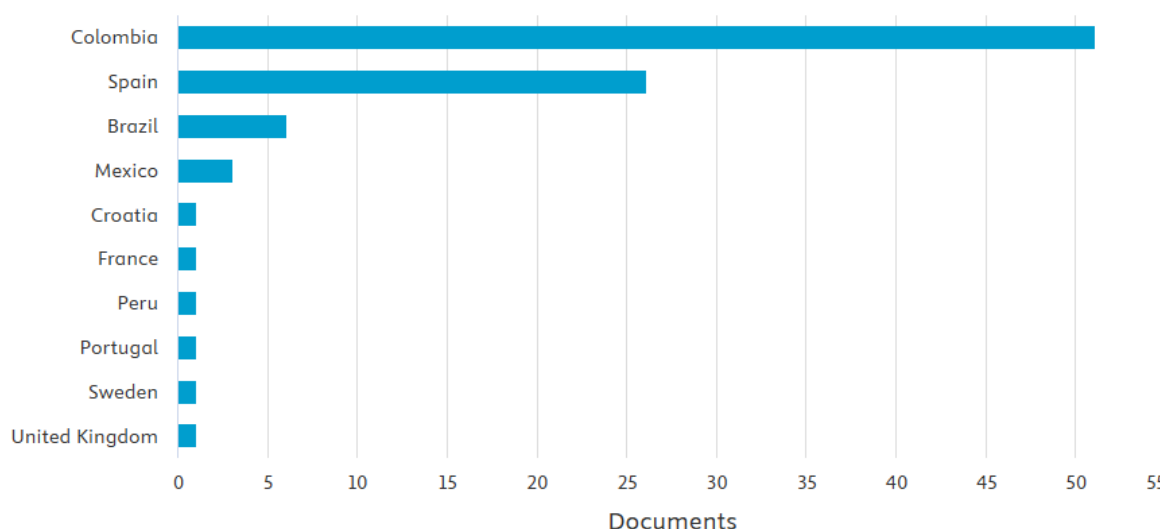


Source: Scopus 2025.

Colombia is among the countries most affected by mercury contamination or poisoning. However, it is not alone. Other Latin American and European countries are also experiencing this problem, and their research has revealed this. Many scientific articles are already showing collaboration between countries to enhance pollution reduction and promote further actions to eradicate this contamination (Chart 2).

Chart 2.

Countries most affected by mercury contamination.



Source: Scopus 2025.

This ethnographic study seeks to interpret the meanings and practices developed by families in the municipality of Ayapel, who live in the lower basin of the San Jorge River, to mitigate the risks of mercury exposure or poisoning derived from mining activities. This study explores the daily and social dynamics of the exposed community, in a context of increasing vulnerability due to artisanal mining. The results reveal families' perceptions and attitudes toward mining activity and the associated risks, with a particular focus on mercury. The findings are presented organized into predefined analytical categories, derived from both the literature reviewed and emerging themes during the fieldwork. These results are referenced with the voices of participants, collected through focus groups and interviews.

The research is divided into three main areas: first, the meanings constructed by families in relation to mining activity; second, the practices they develop to mitigate the risks of mercury exposure; and, finally, the meanings attributed to these mitigation practices. The families participating in the study expressed diverse opinions about the harm caused by mercury. For some, it is simply something mentioned among neighbors, while for others, it is a problem identified through readings or shared stories. In Ayapel, cases

of serious illness have been reported, and many people link these problems to mining and chemicals used in agriculture. Several deaths of young people have been reported in the community, and although the exact cause remains undetermined, some believe it could be related to mercury contamination. These perceptions reflect the uncertainty and diffuse knowledge in the community about the effects of mercury exposure, an issue that remains unresolved despite growing concern in the area (Table 1).

Table 1.

Coding

Category	Sub-Category	Context	Coding
Practice	Personal hygiene methods	It refers to the personal hygiene practices used by Ayapel miners and their families to reduce the contamination received when handling mercury for gold extraction.	<ul style="list-style-type: none"> ❖ They wash their hands with soap, then bathe immediately, and barely. ❖ And what do they bathe with? Regular water with soap. Regular water with any soap. ❖ Because the clothes are very dirty, they wash them separately, and then wash the rest. ❖ When the mercury is poured out, everyone goes home to bathe and eat. Only the owners or the caretaker remain. ❖ The mercury is stored outside in a special jar.
Practice	Clothing and apparel	Tools and clothing used by the miners surveyed to protect themselves and their families from mercury exposure, as well as the actions taken to clean it.	<ul style="list-style-type: none"> ❖ “The problem is that they wear clothes appropriate for work. ❖ And the clothes they take home never arrive when they need to wash or take them down.” ❖ I once made their uniform. You, well, I made them pants, a longer shirt, a blouse, that kind of thing. And then for work, that.”
Practice	Assimilated behaviors	These are understood as the actions taken by the families of the miners consulted with the goal of reducing or avoiding contamination after a day's work and thus exposure to mercury.	
Meaning	Danger awareness	This refers to the perception of danger that members of families dedicated to mining have in relation to the degree of danger, consequences of exposure, and illnesses resulting from the handling of mercury for gold extraction.	<ul style="list-style-type: none"> ❖ I've never been to a doctor. I'm 67 years old, and I've never been to a doctor. ❖ They go to the mine, the wife, the husband, the children, everyone.

<p>Meaning</p>	<p>Environmental Health and Biodiversity</p> <p>This aspect analyzes how Ayapel residents perceive the health of the natural environment, including local biodiversity. This includes observations about the presence of wildlife, changes in flora and fauna, and the overall perception of ecosystem health.</p> <p>❖ We're working with the same water, reusing it. Reusing the water. We're not polluting.</p> <p>❖ What do the animals get sick from? - I don't know, they get a little bit like this. Others of us came here from the vet, they gave us the drug, but this is normal, like here in Ayapel, which is somewhere else, like right now, the same stench. They fall with their heads down there, and I don't decide anything else. And they die. Está en el ambiente. Porque esa agua se evapora y entonces en el ambiente queda.</p>
<p>Practice</p>	<p>Water Quality</p> <p>This refers to how mining families and other residents of Ayapel perceive the water quality in their environment. This includes their observations of changes in color, odor, taste, and the presence of visible residues in the water.</p> <p>❖ Where this water will fall here, there's a hole where we removed the soil. From that hole, it falls into another hole. That water comes out filtered.</p> <p>❖ For example, right now we're working through... You removed it and poured it into the same hole, and in the same water you're pouring in, you're recycling it. Yes, exactly. We're working with the same water, reusing it. Reusing the water. We're not polluting.</p> <p>❖ Exactly. I mean, that's what stays there. The water and the mercury stay in that hole. The clear water comes out on top, because that goes from one thing to another.</p> <p>❖ When it makes the droplet, it expands. It expands, and the environment enters it. When we discard it, it goes into the water, and you don't see it.</p>

Source: Prepared by the authors.

The use of mercury remains a widespread practice in artisanal mining, primarily due to the lack of accessible and affordable alternatives. Despite the known dangers of this heavy metal, the cost and difficulty in accessing cleaner and more efficient technologies have limited the adoption of less toxic extraction methods. Many miners mentioned that, although they understand the risks, they lack viable options to replace mercury in their processes and instead venture into its conscious use. One of the most compelling findings of the study is the negative impact of mercury on the health of miners and their families. Illnesses associated with mercury exposure are a constant concern. Among the most common problems mentioned are respiratory difficulties, skin disorders, fever, and other widespread health issues. The effects of mercury are also linked to chronic diseases such as diabetes and hypertension, and some family members expressed that women are the most affected due to their exposure not only through mining work, but also through domestic activities, such as preparing food or washing mercury-

contaminated clothing, and being in close proximity to husbands and children who are exposed to mercury on a daily basis.

The families surveyed also adopt daily practices to mitigate the risks of mercury exposure. Regarding personal hygiene methods, miners' families use procedures such as handwashing with soap and regular bathing after mining work, ensuring that clothing worn in the mine is washed separately to prevent mercury from spreading to the home. These actions are intended to protect both workers and their families from mercury contamination. Among the responses obtained in the focus groups and interviews, statements such as: "They wash their hands thoroughly, then shower immediately, and barely do so." "Because they are very dirty, they wash their clothes separately, and then wash the rest." and "When the mercury is spilled, everyone goes home to bathe and eat, only the owners or the person in charge remain." These responses demonstrate that, although the risks are recognized, the measures adopted are, in many cases, reactive and do not systematically prevent exposure. In terms of clothing and attire, the miners mentioned the use of special clothing for mining work, which should never be mixed with household clothes. Clothing is washed separately, and some miners used clothing tailored for their work. Examples of responses such as: "The problem is that they wear clothes appropriate for their work. And the clothes they take home never make it to the time they use to wash or take them down." and "We normally wear our work clothes." demonstrate how clothing plays a crucial role in reducing exposure.

Regarding assimilated behaviors, many participants indicated that, after a day's work in the mine, they wash outside the house to avoid contaminating the home. Also mentioned was the practice of leaving clothing and shoes used in the mine outside the house to prevent mercury from coming into contact with other surfaces. Some of the most common responses in this regard were: "I have a small bathroom outside where we do our business. We bathe there." and "We drown it ourselves. That doesn't go into the houses. Those clothes are from the mine. They stay out here."

In addition to these mitigation practices, awareness about the dangers of mercury is a recurring theme among participants. Many have heard about the dangers of exposure, although most of the time no systematic preventive measures are taken. Examples of responses such as "I've never been to a doctor. I'm 67 years old and I've never been to a doctor." and "They go to the mine—the wife, the husband, the children, everyone." underscore a widespread perception of danger, although some do not seek medical treatment or show full awareness of the seriousness of the risk.

Regarding environmental health and biodiversity, the residents of Ayapel view the natural environment critically. They often mention that they use the mine's water for other activities without adequate treatment, raising concerns about the long-term effects of contamination. Responses obtained in the interviews include: "We're working with the same water, reusing it. We're not polluting." and "What are the animals getting sick from? I don't know, they get a little bit of it, others come here from the vet, they prescribed drugs, but this is normal."

Regarding water quality, many miners indicate that they recycle the water used during mining activities, which means that mercury and other contaminants remain in the water. Some pointed out that filtration in mine shafts can make the water appear cleaner, but it still contains hazardous waste. Statements such as "Exactly. I mean, that's what stays there. The water and the mercury stay in that shaft. The clear water comes out on top." and "We're working with the same water, reusing it. We're not polluting." These statements highlight the recycling of water, but also a lack of awareness of the risks this entails.

In general, damage to the environment and natural resources is a constant concern for the inhabitants of Ayapel. Air, water, and soil pollution continues to be one of the main problems in the region. Mining activities directly impact the natural resources of the lower San Jorge River basin, lakes, and small tributaries that flow into the swampy complex, affecting biodiversity and ecosystems. Miners, although aware of the environmental damage, continue their activities due to the lack of viable economic alternatives.

Social stigma toward artisanal miners also emerges as a recurring theme. Many miners feel criminalized by authorities and society due to the perception that artisanal mining is dangerous or illegal. This stigma is reflected in the treatment they receive from the police and other social actors, generating an atmosphere of mistrust and fear among the miners. The lack of institutional support to regulate mining and improve miners' working conditions is a constant concern. Many miners are forced to work informally, which exposes them to additional risks.

DISCUSSION

The findings reveal that family practices regarding mercury contamination are deeply influenced by structural, sociocultural, and economic factors. Despite the limited knowledge some families have about the risks of mercury, as documented in previous research (Villalobos, 2019; Muñoz-Vallejo et al., 2012), everyday behaviors persist that perpetuate exposure, in part due to the normalization of risk and the limited institutional availability of community support.

Chronic exposure to mercury, especially in artisanal mining areas, continues to be a public health problem in Colombia, as various studies have shown (Gracia et al., 2010; Vargas-Licona & Marrugo-Negrete, 2019; Palma-Parra et al., 2019). In this context, families develop coping strategies that combine empirical knowledge and local wisdom, such as modifying food preparation, consuming certain "detoxifying" products, and using traditional medicine practices. These actions, although well-intentioned, are insufficient from a biomedical perspective to counteract the neurotoxic effects of mercury documented by the WHO (2013, 2016) and by studies such as that of Espitia-Pérez et al. (2016). Another relevant finding is the existence of family resilience mechanisms, understood as adaptive processes that allow families to reorganize in the face of adversity (Arciniega, 2005; World Bank, 2016). Mutual support networks between families and communities represent a key strength, although they do not replace the State's responsibilities in guaranteeing the right to a healthy environment (Repetto, 2010; WHO, 2006).

Institutional measures remain weak and disjointed. Although Law 1658 of 2013 marked a milestone in the regulation of mercury use in Colombia, its implementation has been limited and has not sufficiently permeated the community level (Ministry of Environment, 2013; Casas et al., 2015). This is consistent with the assessment by Mosquera et al. (2018) regarding the limited environmental and social information available in mining areas.

Family risk perception is mediated by direct experience with illnesses, especially in children and older adults, reinforcing the need for interventions from a public health perspective with a territorial focus (MSPS, 2019; DNP, 2021). Successful programs in other contexts have integrated active community participation in risk identification and the implementation of healthy environments (PAHO/WHO, 2006; Taylor & Bogdan, 1987).

The need to advance intercultural and transdisciplinary intervention strategies that articulate scientific knowledge with community practices is highlighted, recognizing family dynamics as a fundamental axis for risk management (Pérez-Pimentel, 2009; Gallego-Henao, 2012). The approach should include educational activities, clinical monitoring, effective environmental regulation, and psychosocial support, with a clear human rights and environmental justice perspective.

CONCLUSIONS

This study highlights the capacity of families in the municipality of Ayapel, located in the lower basin of the San Jorge River, to develop adaptive practices and cultural strategies to address the risks associated with mercury contamination from artisanal mining. The findings suggest that, despite economic and social limitations, these communities have built empirical knowledge based on their daily experiences, allowing them to identify, prevent, and partially mitigate the adverse effects of mercury on their health and environment. Through this knowledge acquired over generations, families have created informal prevention systems that allow, albeit in a limited way, to reduce mercury exposure, albeit without formal intervention or more advanced technologies. However, their response capacity is restricted by structural and contextual factors that impede the implementation of more effective practices.

The perception of risk associated with mercury is mediated by cultural, social, and economic factors, which influence how families prioritize their mitigation actions. Vulnerable conditions, such as lack of access to basic services, education, and healthcare, limit families' ability to implement more effective mitigation strategies. The daily practices described, such as washing clothes and bathing after working in the mine, are evidence of risk perception, but also demonstrate the limitations of available resources. Many miners understand the risks, but the lack of accessible and affordable clean work alternatives leads them to persist in using mercury. Furthermore, mercury use remains a necessity for subsistence, given the absence of other sources of income in the region, which reinforces their perception of risk and also the normalization of this risk within their daily routines.

The results obtained in this study complement previous research documenting the socio-environmental impacts of artisanal mining in vulnerable regions. However, this work differs by focusing on the cultural

and everyday strategies that families develop to mitigate these risks. Unlike other studies, which have approached artisanal mining from a more ecological or public health perspective, this study provides a more humane and culturally informed view of the daily practices and meanings families attribute to mercury risk and exposure. These mitigation practices, although rudimentary, reveal a constant process of adaptation that occurs in response to the situation of vulnerability.

The use of an ethnographic approach allowed us to capture nuances in local perceptions and practices that would not have been evident through more structured methodologies. The families' interpretation of the meanings attributed to risk highlights the importance of integrating community voices into the design of public policies and intervention programs. This participatory approach facilitates a deeper understanding of local values and beliefs, which is essential for designing culturally appropriate and socially acceptable solutions. The voices of mining families underscore the need for any intervention to consider their context and for them not to be perceived solely as victims of mercury, but as key actors in the creation of sustainable solutions. Furthermore, the findings underscore the need for interdisciplinary approaches that combine scientific knowledge with traditional knowledge to address complex problems such as mercury contamination. This implies recognizing communities as co-creators of solutions and not merely recipients of external measures. Families' cultural practices and empirical knowledge must be taken into account to complement scientific interventions, since, as observed, completely external solutions are often ineffective in local contexts where implementation is difficult due to a lack of resources, training, and institutional support.

On the other hand, the study's limitations, such as the limited representativeness of the sample and the logistical difficulties arising from access to the territory, reinforce the importance of continuing research in this region, expanding participation and exploring the impact of specific interventions in the local context. While the study offers valuable insight into the practices and meanings of a segment of the mining population, a broader approach encompassing a larger number of families and localities is necessary to generate more robust and generalizable conclusions.

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