Perception of mercury contamination by Brazilian adolescents in a gold mining community: an ethnographic approach

Percepção da contaminação por mercúrio entre adolescentes de uma comunidade em área de garimpo de ouro: uma abordagem etnográfica

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Abstract ***This study used ethnographic methods to examine the perception of mercury contamination by adolescents in the mining community of Poconé, Mato Grosso, Brazil. In Phase I, 53 students aged 13 to 16 years in six schools presented theatrical sketches about community health risks to generate key terms for a pile sorting activity in Phase II. Mercury was reported by four of the 15 groups (26%). In Phase II, researchers conducted semi-structured interviews and pile sorts with 31 students to assess adolescent attitudes about mercury and to generate an ethnomedical model of mercury perception. The lack of consensus evident in the model reveals that while students view mercury as an overall threat, many of them do not understand how its presence can harm human health. Few adolescents felt confident about their knowledge (3%) or could accurately explain how it was used (9%), even though many of them had relatives working as miners (55%). Further analysis of pile sort data suggests that mercury may not belong in a "typical risks" domain. The authors argue that ethnographic methods are a useful tool for public health research, and hope that these findings can contribute to health education interventions in the field.***

Key words ***Mercury, Contamination, Risk perception, Adolescents, Ethnographic method, Health education***

Resumo ***Foram utilizados métodos etnográficos para avaliar a percepção de adolescentes escolares sobre a contaminação por mercúrio na cidade de Poconé, Mato Grosso, Brasil. Na Fase I, 53 estudantes (13 a 16 anos de idade) de seis escolas do ensino fundamental apresentaram aos pesquisadores temas sobre saúde pública que geraram palavras-chave para a Fase II (cartões-estímulo). Mercúrio foi citado por quatro dos quinze grupos (26%) formados por dois a cinco estudantes. Na Fase II, os pesquisadores realizaram entrevistas semi-estruturadas e cartões-estímulo em 31 estudantes para avaliar atitudes sobre mercúrio que geraram um modelo etnomédico. A falta de consenso evidenciada neste modelo revelou que enquanto alguns estudantes percebiam o mercúrio como uma ameaça, outros desconheciam como sua presença poderia afetar a saúde, poucos eram confiantes sobre seu conhecimento (3%) ou poderiam explicar com detalhes como era utilizado (9%), embora possuíssem parentes trabalhando como garimpeiros (55%). O mercúrio como um "risco típico" também não faz parte do domínio do conhecimento destes adolescentes. Os autores sugerem que métodos etnográficos possam ser uma ferramenta útil para a Saúde Coletiva e esperam que estes resultados possam contribuir para novas intervenções em educação para a saúde neste tema.***

Palavras-chave ***Mercúrio, Contaminação, Percepção de risco, Adolescentes, Método etnográfico, Educação para saúde***

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Introduction

Mercury (Hg) is a toxic heavy metal capable of causing acute, and principally, chronic poisoning in human beings, with lasting effects on the nervous system[1]. In Brazilian gold mines, mercury poisoning occurs when miners use mercury—which binds to gold in an amalgam (Hg-Au)—to facilitate the identification of gold, which is difficult to extract in its powdered form. After blending approximately one kilo of mercury for every kilo of gold[2], the gold-mercury amalgam is subsequently burned, purifying the gold and releasing mercury into the atmosphere. Gold produced in the mines is sold to stores for resale, where storeowners further purify the gold, releasing mercury into semi-urban and urban areas. Importantly, the metallic mercury vapor may also undergo a methylation process in river sediments, intoxicating fish and other wildlife and creating an additional pathway (via ingestion) for mercury exposure in the general population[3]. As a result, people adversely affected by mercury include: miners and storeowners who physically manage the production of gold, non-miners who frequent locations close to gold production sites (mines, stores), and those who ingest contaminated fish.

Since 1980, Brazil has been the leading producer of gold in Latin America. Though gold production has decreased over the last fifteen years, mining remains an established economic activity in many locales, including Poconé (population: 30,773), where over 3000 kg of gold are produced every year. Home to sixteen mining cooperatives, Poconé is located in Central-western Brazil in the state of Mato Grosso[4]. It is one of several entrance points into the Pantanal—the world's largest wetland, a World Heritage Site, and an ecosystem containing great biodiversity.

Previous research conducted in Poconé identified mercury contamination in mines and homes where individuals prepared gold for sale[5]. Researchers noted significant contamination in human urine—as high as 16.62 mg/l in schoolchildren—as well as dust and soil samples, taken from both the center and periphery of Poconé. Residents from the periphery with high mercury levels admitted to burning mercury-gold amalgams inside their own houses[5]. These and other studies indicate a clear need for health interventions in Poconé[5,6].

Research goals: theory, assessment, practice

People develop attitudes, beliefs and behavioral responses in reaction to environmental hazards, such as mercury contamination, through a complex process characterized by cognitive and affective, as well as individual and social dimensions. Research suggests that people learn about environmental hazards from a variety of sources, which may or may not reflect scientific evidence[7,8]. Individuals respond to this information by assessing the possibility that they will personally experience risk—that is, negative effects from exposure to the hazard[9]. Their assessment results in risk perception, the attitudes and beliefs that comprise their judgment about the nature and probability of potential harm to themselves.

An individual's risk perceptions are influenced by the accuracy of the information, the source of the information, and the nature of the individual's relationship to that source. When individuals are closely interconnected in a social network, risk communication theories suggest that they will share similar "information, attitudes, and beliefs"[10]. If the information used to form risk perceptions is inaccurate or incomplete, unofficial messages not grounded in scientific theory may take root in the social network and the community at large[11].

Regardless of whether they are given accurate or inaccurate information, individuals and groups filter and alter what they hear, depending on personal and social experiences and motivations[12]. People may also be motivated to invent heuristics that reduce risk[13], resulting in risk perceptions that exempt themselves from personal harm.

Ultimately, the interplay of complex factors results in risk perceptions that can benefit or harm human health[14] and researchers have not yet developed models that adequately describe this complex process. In the area of risk perception, there is a need for theoretical development that addresses risk perception at both individual and group levels, while incorporating the affective and cognitive factors that influence judgments[15,16]. To this end, the present study aimed, in part, to develop an ethnomedical model of risk perception that can explain how individuals, who are interconnected in a social network, integrate beliefs about causes, symptoms and effects of specific health risks in a community. Ethnomedical models diverge from the "mental models" approach[17] by using community beliefs, rather than expert knowledge, as their foundation[18].

In addition to developing theories to explain how individuals form risk perceptions, scholars

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have suggested that we need better methods to assess perceptions of risk in order to design and implement effective public health interventions[17]. Assessment tools need to be able to measure the influences stemming from both individual and group attitudes and beliefs. When combined with individual interviews, cultural domain analysis[19] represents this kind of comprehensive approach.

Cultural domain analysis is the study of how people within a particular context think about relationships between ideas and is often used when studying illness[20, 21]. Cultural domain analysis can encompass several techniques, including free lists, sentence framing, and pile sorts. Free pile sorts[22] allow interviewees to cluster words and/or concepts according to their own criteria. Aggregated across individuals, pile sorts are powerful tools for constructing semantic associations within a group of individuals because they provide data about how participants perceive various risks in the community in relation to one another. Tools such as these, derived from cultural domain analysis, are rarely, if ever, used to measure risk perception in relation to environmental hazards. We adapted and piloted these tools in the present research in order to enhance our understanding of mercury perception in Poconé and to contribute to the development of appropriate assessment tools for measuring risk perception in relation to exposure to mercury.

In addition to theoretical and methodological objectives, our research also was designed with the objective of improving health outcomes for people at risk of mercury exposure. Children and adolescents are important targets of public health initiatives in mercury-threatened communities because young people—due to their rapid growth and development—are most vulnerable to heavy metal intoxication; and, despite being at the top end of the childhood age range, adolescents are susceptible to adverse effects at relatively low levels of contamination, when compared to adults[23]. Therefore, an accurate picture of mercury risk perception stands to benefit local health and education officials.

More broadly, better risk perception models and assessment tools will enable public health experts to implement more effective interventions. Effective public health interventions must counteract information gleaned from non-scientific sources by transmitting accurate, complete knowledge about mercury and its hazards. The school setting is an ideal location for dissemination of this knowledge, where information can be integrated via new approaches into science curricula. Since adolescents comprise the future miners, leaders, and parents in the community, public health interventions targeted to this group can potentially result in long-term benefits for the community of Poconé. Moreover, since Poconé is only one of many mercury-affected communities in Brazil, success in Poconé can potentially have far-reaching benefits.

Design overview

This research, conducted from July to September 2007, was part of a larger two-year initiative, led by the Federal University of Rio de Janeiro (UFRJ), to develop a reliable methodology for testing the impact of educational health interventions in mining communities. The UFRJ set a target to reach 20 percent of all 497 seventh-grade students (typically 14 year olds) in Poconé schools, based on a previous study revealing a 4.5 percent mercury exposure rate in the community ($p < .05$). In total, 128 people from six schools randomly selected agreed to participate in some part of UFRJ's research. Each participating student signed an Ethical Consent Form and obtained one parent/guardian signature.

The overall plan for the UFRJ study included: data collection about mercury contamination levels in the community to use as baseline measures, assessment of mercury perception in the community, creation of an instrument to evaluate mercury knowledge, design of a public health intervention derived from the findings of prior research, and implementation of the intervention. This study was conducted prior to designing the public health intervention, but following collection of data about mercury contamination in the community.

In this study, researchers used semi-structured interviews and pile sorts in order to assess adolescent attitudes about mercury and to generate an ethnomedical model for mercury. A pre-study activity, consisting of participant presentations (described in detail below as Phase I), was also conducted to prepare researchers and students for the pile sorts in Phase II. The primary questions guiding data collection for this study were:

(1) How do adolescents in Poconé perceive the causes, pathways, and symptoms of mercury-related health hazards?

(2) How do methods rooted in cultural domain analysis inform the picture of adolescent risk perception?

Phase I: pile sort preparation

Sample and methods

Participant-generated narratives, including open-ended presentations, are especially useful for identifying adolescent constructions of illness, relationships, or sexuality[24]. This activity used open-ended presentations by adolescents to prepare researchers for Phase II pile sorts. The population sample consisted of 128 students in six local schools. Students ranged in age from 13 to 16 years and were seventh graders.

After a brief discussion about health in the community, groups of two to five students were given a week to prepare a presentation on any theme related to work and health. We expected to discover, in the process, which work- and environment-related health risks were important to them, given that mercury is only one of many risks in the community, and not necessarily the most important. Some teachers did not dedicate class time for the preparation of these presentations, which created problems for students who lived far away and were unable to meet with their group outside school hours. As a result, only 53 students presented to researchers. Presentations included speeches, skits, lectures, or interviews, and all groups made posters relating to their presentations.

Using frequency counts, we comprised a list of the 25 most-commonly identified risks—to be used in a Phase II pile sorting activity. The number 25 was chosen in accordance with time constraints; researchers wanted to limit the pile sort portion of the study to approximately 15 minutes, and discovered that 25 terms took about this amount of time to sort.

Chart 1. Most frequently identified work- and environment-related health risks, generated from Phase I presentations (N=15 groups, 53 speakers) in Poconé.

prostitution	assault	pollution
respiratory illness	burning ***(garbage, forest)***	sewage
garbage	fall ***(tumble)***	car accident
mercury	pesticides	stress
death	swelling	loss of fingers
loss of hearing	poisoning	swollen eye
skin allergy	kidney illness	wound
asthma	depression	common cold
back pain		

Results

Most groups blended several themes into their presentations. The most common themes included work accidents (falls, cut hands and fingers) and environmental pollution (garbage, man-made fires, open sewage), mentioned by 73 percent and 46 percent of groups, respectively. In comparison, mercury was highlighted by 26 percent of groups.

Phase II: interviews, pile sorts, and ethnomedical model generation

Building on our Phase I activity, Phase II was designed to assess mercury perception in the community, giving primary consideration to concerns, understanding, and communication of mercury perception. Research methods, consisting of individual interviews and pile sorts, were grounded in the theory described above, and the ultimate goal of the study was to provide practical knowledge to improve health interventions in schools.

Sample and methods

The sample was comprised of all participating students in "School C." We chose to subsample one school for Phase II because our methods were more time intensive and required only 30 participants to reach reliability levels of over 90 percent[25]. School C was selected based on sample size and—importantly—centrality, as the school's location drew students from various regions of the community. In total, all 31 students in "School C," ages 13 to 16 and in grade seven, participated (11 boys and 20 girls).

Individual interviews were conducted to assess adolescent beliefs about mercury contamination's causes, pathways, and symptoms—to be used for the ethnomedical model. Unlike the open-ended presentation assignment in Phase I, the interview questions focused directly on mercury contamination and how adolescents perceived mercury and other mining risks. In total, the semi-structured interview protocol contained 13 predetermined questions, including "How does mercury affect the citizens of Poconé?" and "What is mercury used for?" To force students to think about mercury pathways, all interviewees were also presented the following common community scenario: "A group of friends begin swimming in the pools of water located in the inactive gold mines [assumed to contain mercury]. After

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a month, they realize they have a skin allergy, but nothing more serious than that. Why is this?" Importantly, we also gathered data about the extent of the perceived mercury hazard, including how worrisome the problem was and what, if anything, made it better. Two questions also asked for numerical, Likert-scale ratings of teenage "concern" and "danger," to be used for scatterplot generation in analysis.

Pile sorts were conducted with adolescents to relate mercury to other risks in the community, and to assess the usefulness of cultural domain analysis as a risk assessment tool. After writing the 25 risk concepts (Chart 1) generated from Phase I on a set of index cards, the first author asked each interviewee to "sort the words in groups in the way that ma[de] most sense to [them]." Next, he asked students to explain their methodology and/or give titles to each pile.

First, we used Likert data to generate scatterplots[26]. Scatterplots provide a graphical display of all data, revealing patterns not reflected in averages and standard deviations. Second, we coded the transcribed interviews for patterns and themes in the text according to guidelines put forth by Miles and Huberman[26]. This method divides the coding process into first-pass codes, or straightforward utterances of certain ideas, and second-pass codes, which are more thematic and analytical in nature. In this case, first-pass codes for the interview data focused on explicit statements of symptoms, risks, pathways, and time-scales and included "explicit mention of 'illness'" (ILL) and "explicit reference to quantity" (QNT). Second-pass codes focused on feelings and sentiments associated with the risk and included "feelings of urgency" (FRU) and "feelings of powerlessness" (PWL). Next, interview transcripts were analyzed by constructing a matrix for each interviewee and categorizing their responses[26] into causes, pathways, symptoms, and solutions. The matrix served to condense the data for easier analysis of patterns. "Strong links" were established by identifying nearly universal relationships among categories, while "weak links" were defined by noteworthy (frequent), but not universal, patterns. Following this process, the authors constructed a conceptual model for mercury risk among adolescents in the community, tracing mercury's origin in the mines (***garimpo***) to its ultimate impact on the human body[21]. Finally, we constructed a similarity matrix from pile sort data and used the STATA 10 software package to run a multidimensional scaling analysis (non-metric, loss=stress), in order to create a spatial representation of the domain among adolescents in Poconé. STATA converted similarities into dissimilarities using the standard formula: [dissimilarity = sqrt(2(1-similarity)].

Results

Adolescents' knowledge about mercury's role in mining

Researchers wanted to get a sense for how scientifically knowledgeable students were about mercury and mining, in order to generate "environmental causes" for the ethnomedical model and assess knowledge gaps in the community. When asked about their knowledge directly, all interviewees, except one, indicated that did not feel comfortable speaking in detail about mercury and its hazards; most blamed this knowledge gap on disinterest, inattention or inadequate information in the school setting. Roughly two-thirds (19) of interviewees did not offer an explanation for mercury utilization in the mines, including several who had never heard of mercury before the project. Three interviewees managed to describe the mercury utilization process in some detail.

"***If we look at a piece of earth, we can't tell if there is gold in there. Now, if you arrange the machine and the mercury, then whatever gold exists in the earth will be revealed. I've even seen them burn it. Because afterwards they put the mixture in a plate, an iron plate, and there you burn the mixture***" (Marcos).

Adolescents' beliefs about mercury pathways and symptoms

It was also important for model construction and general understanding to assess adolescent views of perceived mercury pathways and symptoms associated with contamination. When asked "how" mercury affects citizens in Poconé, 52 percent responded with an air/inhalation-based explanation; 29 percent responded with a water/ingestion-based explanation; and 19 percent chose a physical contact-based explanation. Only 54 percent of interviewees answered "Yes" when asked if mercury affects the nervous system—its principal target in the human body. In addition, the vast majority of respondents used broad terms such as "illness" and "poisoning" to describe mercury hazards.

"***I think it's a very strong substance and that it can poison someone. It can cause illness. I would guess that if people are working they could contract an illness from it. Because, for example, I've***

never seen anybody use a mask in the mines" (Tamara).

Respondents replied to the scenario, which asked them to explain why friends who swam in a contaminated pool only developed a skin allergy, in a wide variety of ways, some of which were unrelated to mercury. A scientifically-based explanation for the scenario would highlight the fact that in the water, the mercury is inorganic, not readily absorbed into the body, and therefore not likely to cause symptoms more serious than a skin allergy. We coded their responses into four broad categories.

(1) Risk related to pathways of transmission:

"***For people who swim and don't drink the water, it's fine. They'd have serious effects if they drank the water***" (Dani).

(2) Risk related to quantity of mercury in the water:

"***The fact that the kids aren't suffering serious problems means that there isn't enough mercury in the water to cause problems. I know people who bathe in*** [the inactive mines]" (Gisele).

(3) Risk related to time passed:

"***It could be this mercury. But the effects aren't visible because it starts with the skin and then gets more serious***" (Jorge).

(4) Risk unrelated to mercury:

"***Something in the dirt is causing the allergy, because I have an allergy to the dirt also. The mine was already deactivated, so the products and things that they were using are no longer in use***" (Tamara).

Adolescents' perceptions of mercury risks

It was also important for researchers to understand how serious of a threat adolescents believe mercury is. Students were asked to rate—on a seven-point Likert scale—how concerned they were about mercury (X axis - "worry") and how dangerous of a threat they thought it posed (Y axis – "danger"). Their responses were converted from Likert-scale values (1-not at all worried/dangerous; 4-somewhat worried/dangerous; 7-extremely worried/dangerous) to X,Y coordinates (-3 to 3). Figure 1 presents a scatterplot of Likert scale values measuring "concern" and "danger" for all interviewees in School C.

Virtually all respondents, when asked indirectly about mercury's threat, indicated that that they ***do not*** worry about mercury on a daily basis—including those who said they were worried about mercury on the Likert-style questions. On the scatterplot, adolescents making up the largest cluster fell in the category of "high danger, medium worry." For these individuals, mercury presented a health risk, but not one that worried them daily.

Drawing from research highlighting worry-reducing heuristics, researchers also suspected that mercury perception might be colored by their outlook on the mining industry itself. All interviewees were asked to comment on the "importance", as they saw it, of the gold mines in Poconé. While all but two students indicated that the mines were economically important to the town, the overwhelming majority of respondents qualified their statements with assertions of destruction to the environment and/or risks to workers from mining. In making these assertions, interviewees often distanced themselves from the gold miners, many of whom (55 percent) were fathers, uncles, and cousins to them:

"***The mines are important for the people who work there, but for us, who have nothing to do with it, the mines only do harm to our city***" (Carmela, cousin of gold miner).

"***I don't think that mining is very important here in Poconé, because the mine is only going to harm the environment, it's not going to help anything***" (Marcos, son of gold miner).

Most students indicated that the mines were ***once*** important for the town, but less than half of the interviewees described this importance in the present tense. Many also claimed that government- and commerce-related jobs had now become more respected in the city, relative to mining jobs. In this sense, there appeared to be a clear distinction between what "once was" and what "now is."

"***Certainly there are people who work in the mine and who sustain themselves off of that work. My mom told me that this place was known for its gold, because of the mines, but now I don't think it generates as much***" (Fernanda).

Concern for worker safety was also deeply ingrained in interviewee responses, though students often cited risks other than mercury, such as mine cave-ins, as serious problems:

"***People work*** [in the mines] ***to make money from the gold. But there is also the issue of the mercury, which is harmful. Working in the mine can be quite dangerous, especially since there is a chance that the mine will cave in***" (Ana Flavia).

The environment appeared to be very central to the adolescents' ideas about mining and risk, but for many, mercury was not considered an environmental contaminant. When asked about mining in general, interviewees were most likely

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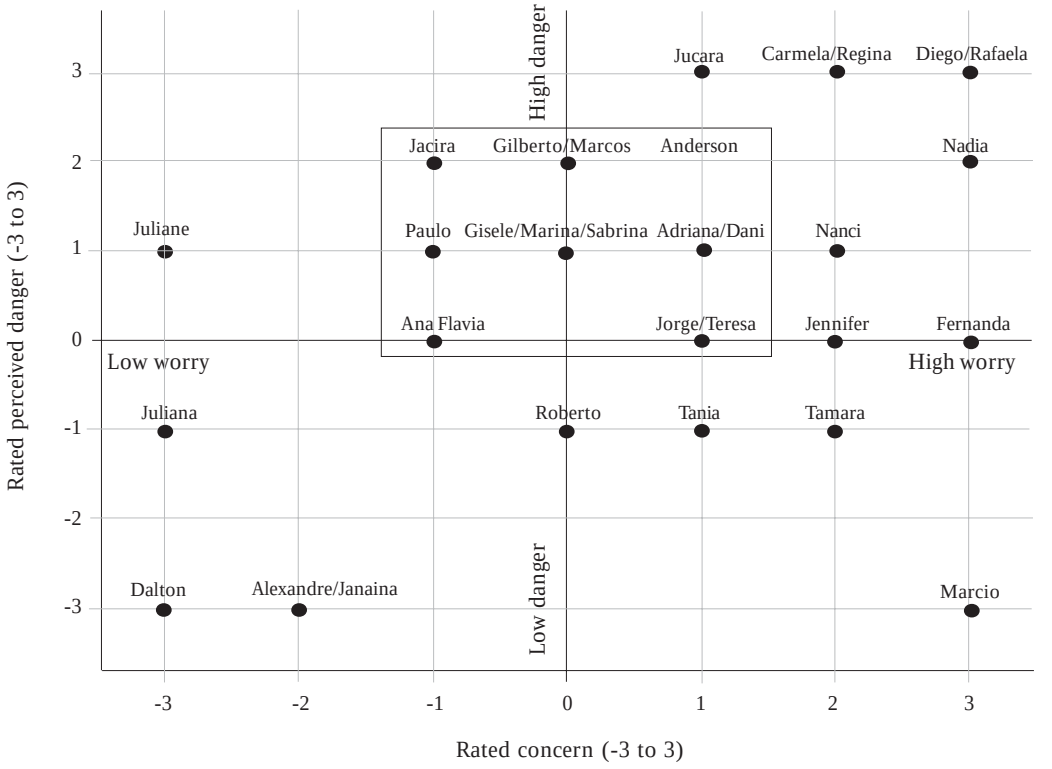

Figure 1. Scatterplot of the association between perceived danger and worry ratings provided by seventh grade students (N=31) from School C.

to mention physical "harm" to or "destruction" of the environment; as an environmental threat, mercury ranked low.

Interview coding also revealed a marked association between the first-pass proximity code and the second-pass distance code. That is, those that mentioned the mines' relative distance from the city were also likely to remove themselves personally from the perceived risk.

"***I think*** [the risk is] ***more in the actual mine. For the people who don't work in the mine, it doesn't really get in the way because the mine isn't really close to the center of the city***" (Marcio).

Using pile sorts to portray risk similarity

We asked participants to categorize 25 work and environment-related health risks to provide researchers with insights about how adolescents view common risks in relation to each other. Results from the multidimensional scaling analysis[27] performed on the pile sort data are presented in Figure 2. Multidimensional scaling analysis converts dissimilarity data in matrix form into a two-dimensional representation of the "distance" between sorted terms. Terms that cluster together are those that are most closely related conceptually, according to the pile sort activity. For this plot, Kruskal's Stress-1 measure (0.13) indicates an acceptable model fit, one far below the level expected if the map did not accurately represent the data[28].

The pile sort activity reveals several important patterns in the way adolescents perceive risks in the community. Virtually all interviewees sorted "sewage," "burning," "garbage," and "pollution" together; many titled this type of grouping "pollution." What could be considered work accidents like "loss of fingers," "back pain," and "a fall," were also often sorted together, but with less frequency.

Interviewees most commonly sorted mercury in piles with "pesticides," "poisoning," "respiratory illness," and "pollution." Several inter-

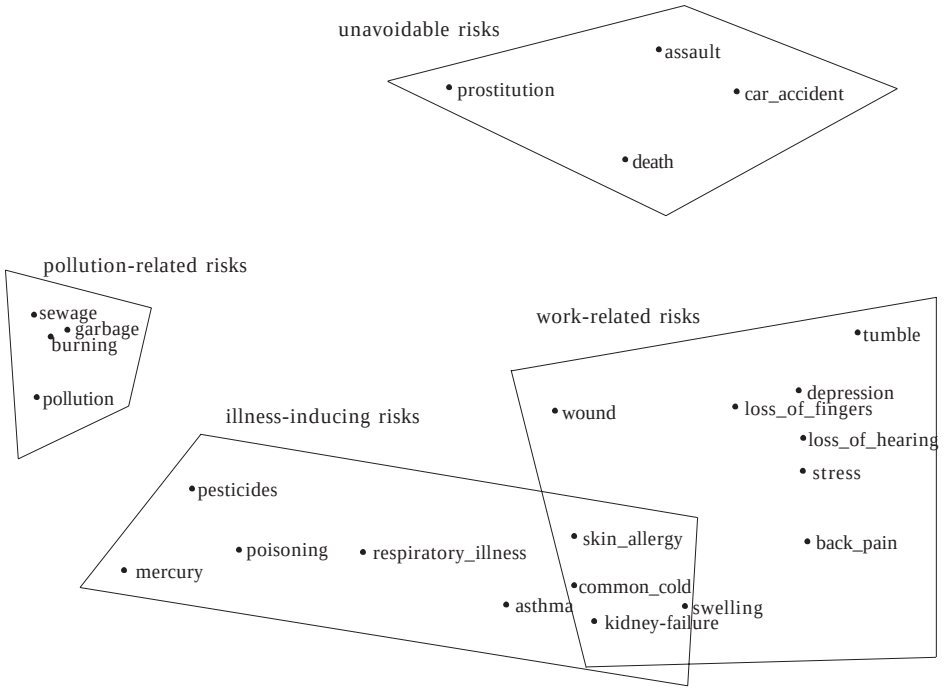

Figure 2. Non-metric Multidimensional Scaling Analysis of Interviewee Pile Sort Data from School C (N=31).

viewees placed it alone, not knowing where it fit into the larger semantic puzzle. "Kidney illness," a common symptom of mercury poisoning, was rarely sorted with mercury.

Ethnomedical model construction

In order to construct an ethnomedical model for mercury perception, researchers reduced and coded data and established "strong" and "weak" links among causes, pathways, and symptoms, as described above. The strength of these links depended on the consensus achieved by participants in our study. Figure 3 shows, for example, that there was little consensus about how mercury comes to affect the human body, but that nearly everyone—regardless of the perceived pathway—agreed that mercury caused "illness" or "poisoning." Weak links were established between ingestion of mercury and vision loss, as well as physical contact with mercury and infection. In some instances, adolescents also believed that the illness induced by contamination led to either death or internal organ damage.

Discussion

The generation of an ethnomedical model for mercury perception—and the use of cultural domain analysis as an assessment tool—was designed to provide a snapshot of adolescent risk perception that reflected the integration of non-scientific information into perception. The techniques presented here succeed in providing risk researchers with a practical basis for targeting knowledge gaps, which should help guide public health interventions. Because both methodologies incorporate common community conceptions and beliefs, rather than relying on survey data about scientific knowledge, they provide a much richer picture of risk perception in communities[21]. In addition to engaging participants to a greater degree, these methods may also provide more accurate information than traditional risk perception questionnaires because they avoid cueing respondents with expert knowledge[17].

Ethnomedical models, constructed pre- and post-intervention, are a promising tool for measuring the success of health interventions. Depend-

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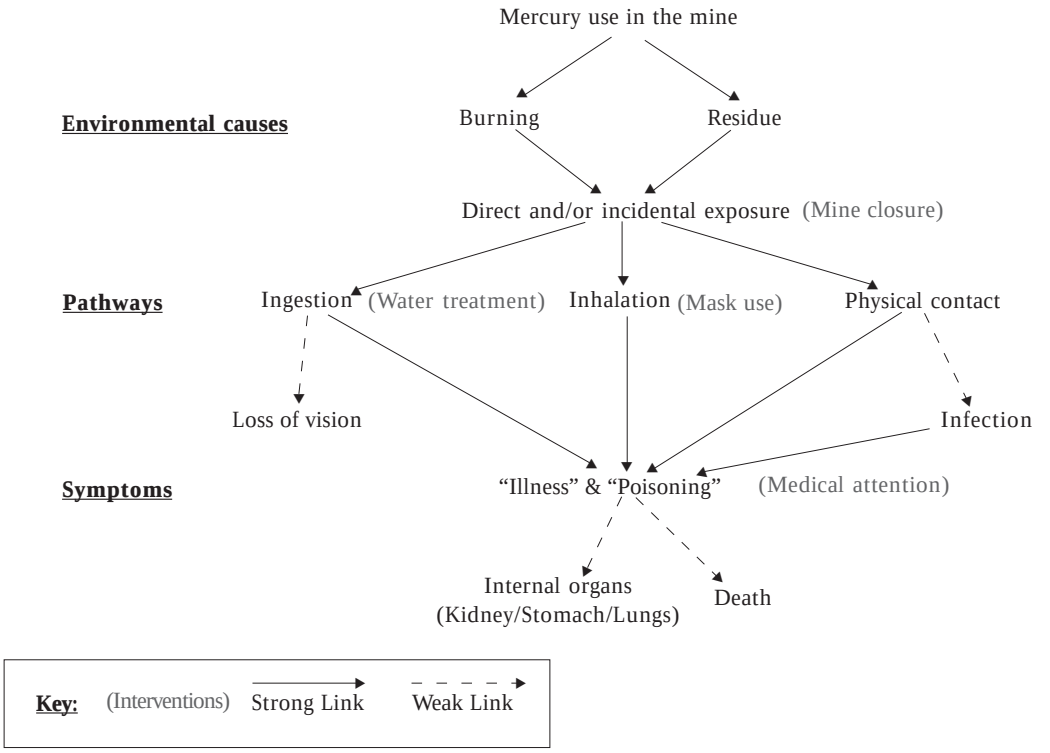

Figure 3. Ethnomedical model of mercury risk among adolescents in Poconé, 2007, constructed from interviews in School C.

ing on the goals of the intervention, a post-intervention model with fewer "weak links" and a closer approximation to scientific reality might indicate changes in knowledge and confidence about health hazards. However, further interdisciplinary research is needed to assess how knowledge is transmitted among informal and formal networks[29]. For example, while it appeared that the majority of people relied on stories heard from others (i.e. "I heard that…") to justify their opinions, we could not make broader claims about how the knowledge was transmitted. This information can be incorporated into existing ethnomedical models and will provide key insights for designing more effective health interventions.

Importantly, neither the model, nor the pile sorts serve as standalone assessments of risk perception. The ethnomedical model shows that nearly all interviewees associate mercury with the general terms "illness" and "poisoning" despite offering different pathways by which mercury affects the human body. The fact that no strong links were established between particular pathways and symptoms reveals a general lack of specificity in adolescent understanding of mercury and its hazards—a result that was confirmed by interview data. Likewise, in pile sorts, mercury's association with dangers such as "poisoning" (several students labeled the pile "severe illness") but not with more specific symptoms suggests that students view mercury as a general threat, but that they may not understand why. But neither tool highlighted low levels of adolescent concern or why adolescents might develop perceptions of no risk.

Addressing these questions requires combining interviews and pile sorts more cohesively. We know from previous research, for example, that individuals who describe mercury's effects in the long-term or only relative to visible contamination, as many did in the skin allergy scenario, are unlikely to preoccupy themselves with mercury[13]. The cultural domain analysis also provides a perspective by showing how adolescents relate mercury to other risks. For example, mercury's distance in Figure 3 from the majority of the other elements indicates that—for adolescents in Poconé—"mercury" may not belong to a "typical risks" cultural domain[20]. One theory is that there

is much less of a clear connection between mercury contact and the mainly internal effects caused by mercury contamination. This might be analogous to UV radiation from the sun or pollution in the air. In contrast, work accidents such as cut fingers and tumbles are clearly connected and easier to understand. To this effect, Slovic[30] classified a series of risks according to "dread risk" (uncontrollable; deadly; risk to future generations) and "unknown risk" (effects unknown; delayed; new risk). Mercury ranked as slightly unknown and slightly dreaded, alongside asbestos, pesticides, and auto lead. By comparison, the risk attributed to radioactive waste was both "dreaded" and "unknown," while handgun risk was ranked as "slightly dreaded" and "known." Mercury's unique physical properties and mysterious pathways are likely at the core of the risk-concern gap in Poconé. Indeed, throughout the interviews, respondents clearly struggled with a central contradiction: if mercury is everywhere in our community, why are we not all getting sick?

Physical proximity to the mines may be another explanation for low levels of concern[12]. Other scholars have described risk perception gaps in situations when residents are able to transfer risk to others[31]. As noted above, many students distanced themselves from personal risk by citing the relative distance of the mines from their homes or a reduced risk in recent years due to the decrease in activities. Mining in Poconé ***has*** decreased over the years, but remains an economic engine for the town (In 2008, production significantly expanded due to rising gold prices). In reality, Poconé experienced an intense process of mechanization, transforming mining activities from small-scale, backyard operations to larger-scale mining controlled by a few large cooperatives. Therefore, many adolescents in Poconé have lost daily contact with the mining process, diminishing their knowledge, and concern, about mercury.

Recommendations for public health interventions

This research has given us several important insights for future targeted public health interventions in Poconé and other environmentally-threatened communities. First, interventions must seek to present information about the links between mercury (or any other risk) and the human body in a form that can be readily understood by the residents. Given the complex relationship between mercury and human health, the authors believe educational approaches must demystify mercury in a concrete way. For example, by taking field trips to mining sites, allowing students to see mercury first-hand, and receiving visits from doctors or authorities other than teachers, students may gain a better grasp of mercury contamination. Second, interventions should seek to identify sources of community knowledge and exploit currently used modes of communication. In Poconé, as with other settings[31], mercury perception is based on a fusion of knowledge accumulated from personal and secondhand experience. Until now, school curriculum and government interventions appear to have had a limited effect on mercury awareness. Third, the authors strongly believe that interventions should seek to involve students in an active and participatory manner, as student-centered activities will take advantage of peer influences to transmit knowledge. Rather than using expert-based knowledge delivery, public health projects should make students the principal authors of their own learning. We have had success in other locales using student-created theater and film to promote mercury awareness[5]. The authors believe that crafting interventions with these principles in mind will help to bridge knowledge gaps, increase student confidence, and ultimately, influence decision-making in a way that promotes adolescent health.

Limitations

There are two primary limitations associated with this study. First, a small sample size in both Phase I and Phase II has the potential to limit the study's generalizability. During Phase I, the authors determined that despite the small sample, the data varied enough to elicit keywords for the pile sort activity. In Phase II, sample size was intentionally small, as methodological and logistical considerations rendered studying one-classroom in full ideal. Nonetheless, while our results may not transfer to other mining communities, the methodology for generating these findings should prove useful in other communities. Second, there are important tradeoffs associated with a non-resident's status in the community. All of the authors could communicate effectively with the participants, but several respondents were non-verbal, nervous, or reserved, perhaps having to do with seeing the researchers as outsiders. Despite these issues, the variety and scope of the data gathered provides a detailed picture of adolescent risk perception in Poconé.

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Colaborators

G Novais was responsible for research design, data collection, analysis, and writing. VM Câmara contributed to the introduction and literature review and guided the analysis as an adviser.

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References

1. World Health Organization. ***Inorganic mercury***. Geneva: WHO; 1991.
2. Pfeiffer WC. Controle da poluição por mercúrio nos garimpos de ouro. In: Câmara VdM, editor. ***Mercúrio em áreas de garimpos de ouro***. Metepec, México: Centro Panamericano de Ecologia Humana e Saúde (ECO/OPS); 1993. p. 129-138.
3. Davidson PW, Myers GJ, Weiss B, Shamlaye CF, Cox C. Prenatal methyl mercury exposure from fish consumption and child development: A review of evidence and perspectives from the Seychelles child development study. ***Neurotoxicology*** 2006; 27(6):1106-1109.
4. METAMAT - História [homepage on the Internet]. [cited 2008 Jul 31]. Available from: http://www.metamat.mt.gov.br/page1.php
5. Câmara VM, Tavares LMB, Filhote MIF, Malm O, Perez MA. A program for the control of indoor pollution by metallic mercury. ***Environ Res*** 2000; 83(2):110-116.
6. Hacon SS, Barrocas PRG, Vasconcellos ACS, Barcillos C, Wasserman JC, Campos RC, Ribeiro C, Azevedo-Carloni FB**.** An overview of the mercury contamination research in the Amazon basin with emphasis on the Brazilian region. ***Cad Saude Publica*** 2008; 24(7):1479-1492.
7. Douglas M. ***Risk & blame: Essays in cultural theory***. London: Routledge; 1994.
8. Joffe H, Lee NYL. Social representation of a food risk: The Hong Kong avian bird flu epidemic. ***J Health Psychol.*** 2004; 9(4):517-533.
9. Renn O. Three decades of risk research: Accomplishments and new challenges. ***J Risk Res*** 1998; 1(1):49-71.
10. Scherer CW. Community network linkages during a health controversy. ***J Public Health Manag Pract*** 2000; 6(2):21-29.
11. Fessenden-Raden J, Fitchen JM, Heath JS. Providing risk information in communities: Factors influencing what is heard and accepted. ***Sci Technol Human Values*** 1987; 12(3/4):94-101.
12. Masuda JR, Garvin T. Place, culture, and the social amplification of risk. ***Risk Anal*** 2006; 26(2):437-454.
13. Grasmück D, Scholz RW. Risk perception of heavy metal soil contamination by high-exposed and low-exposed inhabitants: The role of knowledge and emotional concerns. ***Risk Anal*** 2005; 25(3):611-622.
14. Salazar MK, Napolitano M, Scherer JA, McCauley LA. Hispanic adolescent farmworkers' perceptions associated with pesticide exposure. ***West J Nurs Res*** 2004; 26(2):146-166.
15. Boholm A. Comparative studies of risk perception: A review of twenty years of research. ***J Risk Res*** 1998; 1(2):135.
16. Sjoberg L. Factors in risk perception. ***Risk Anal*** 2000; 20(1):1-11.
17. Morgan MG, Fischoff B, Bostrom A, Atman CJ. ***Risk communication: A mental models approach.*** Cambridge; New York: Cambridge University Press; 2002.
18. Alladin WJ. The ethnomedical model as a conceptual tool for counselling in health-care decision-making. ***Br J Guid Counc*** 1993; 21(1):8-19.

19. Bernard HR. ***Research methods in anthropology: Qualitative and quantitative approaches.*** Lanham, MD: Rowman Altamira; 2006.
20. Borgatti SP. Cultural domain analysis. ***Journal of Quantitative Anthropology*** 1994; 4(4):261-278.
21. Gittelsohn J, Harris SB, Burris KL, Kakegamic L, Landman LT, Sharma A, Wolever TM, Logan A, Barnie A, Zinman B. Use of ethnographic methods for applied research on diabetes among the Ojibway-Cree in northern Ontario. ***Health Educ Behav*** 1996; 23(3):365-382.
22. Burton ML, Romney AK. A multidimensional representation of role terms. ***Am Ethnol*** 1975; 2(3):397-407.
23. Hersztan J. Considerations of susceptible populations. ***Textbook of Clinical Occupational and Environmental Medicine.*** Philadelphia: WB Saunders; 1994.
24. Rich M, Chalfen R. Showing and telling asthma: Children teaching physicians with visual narrative. ***Visual Studies*** 1999; 14:51-71.
25. Weller SC, Romney AK. ***Systematic data collection.*** Newbury Park, CA: Sage Publications; 1988.
26. Miles MB, Huberman MA. ***Qualitative data analysis: An expanded sourcebook***. Thousand Oaks, CA: Sage Publications; 1994.
27. Kruskal JB, Wish M. ***Multidimensional scaling***. Beverly Hills, CA: Sage Publications; 1978.
28. Sturrock K, Rocha J. A multidimensional scaling stress evaluation table. ***Field Methods*** 2000;12(1):49-60.
29. Scherer CW, Cho H. A social network contagion theory of risk perception. ***Risk Anal*** 2003; 23(2):261-267.
30. Slovic P. Perception of risk. ***Science*** 1987; 236(4799):280-285.
31. Bickerstaff K, Walker G. Public understandings of air pollution: The 'localisation' of environmental risk. ***Global Environ Change*** 2001;11(2):133-145.

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