

Educational Trainings and Retort Distribution Reduce Mercury Emissions in Artisanal and Small-Scale Gold Mining Communities in Senegal

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KEY POINTS

- We evaluated an intervention to reduce mercury emissions in artisanal and small-scale gold mining communities in Kedougou, Senegal.
- We combined an educational training using graphics based, culturally appropriate, and community-oriented approaches with distribution of locally produced and affordable retorts.
- The intervention led to increased knowledge that mercury is dangerous.
- The intervention led to increased retort use.
- We observed a social spillover effect, wherein people who had not directly received the intervention also demonstrated knowledge increases and behavior change.

BACKGROUND

Artisanal and small-scale gold mining (ASGM) is the main contributor of mercury pollution to the atmosphere globally (1). The UNEP's Minamata Convention on Mercury Article 7 specifically calls for countries to reduce mercury emissions associated with ASGM. Mercury is a potent neurotoxin that can have harmful effects on both people (2) and wildlife (3). Once mercury enters the body, it can cause limb tremors, blurred vision, loss of limb functionality, and in severe cases, death (2). In the ASGM process, small groups of miners extract soils and sediments, which they mix with mercury. Mercury selectively binds to the gold, forming a mercury-gold amalgam that can be separated from the rest of the soil and sediment. However, excess mercury enters soils and rivers, while mercury that is burned off from the

amalgam is released into the atmosphere and later re-enters land and water.

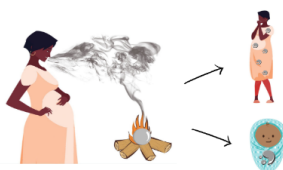
Miners are exposed to mercury through direct skin contact and inhalation of mercury vapors. As burning of the mercury-gold amalgam often occurs within communities and/or urban areas, community members, including non-miners and children, are also affected through inhalation of airborne vapors, contamination of living areas, and/or consumption of mercury-laden food (4). In the Kedougou Region of Senegal, ASGM activity has increased since the 1970s, especially over the past decade, leading to a ten-fold increase in gold production. Today, over 75% of the regional population is currently associated with ASGM activities, either by directly mining or by contributing to the local economy (e.g., vendors, transportation) (5, 6).

Protégez-Vous Contre la Toxicité du Mercure Provenant de l'Exploitation Minière

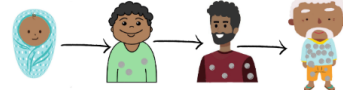
Comment le Mercure Pénètre dans Votre Corps



Le mercure brûlant se déplace vers les maisons et les personnes voisines



Le mercure entre par le nez ou la bouche lorsque vous êtes près d'un endroit où du mercure est brûlé. Les mères peuvent le transmettre à leur bébé.



Si vous continuez à respirer du mercure, il s'accumule dans votre corps. Le mercure reste dans votre corps.

Effets Secondaires de l'Exposition au Mercure



Problèmes liés à la parole et à l'audition



Problèmes oculaires, la vision devient floue.



Difficulté à serrer la main et tremblements du corps



Oubli et difficulté à se souvenir



Corps partiellement engourdi et difficulté à bouger les parties du corps



Décès

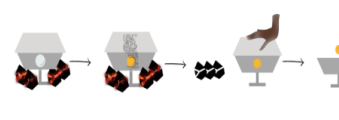
Comment Vous Protéger du Mercure



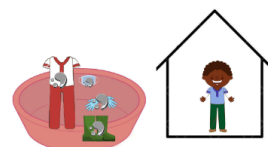
Portez des gants, un masque et des chaussures pour toucher ou brûler du mercure



Brûler du mercure dans une zone éloignée de la communauté



Utilisez une cornue pour empêcher les vapeurs de mercure de s'échapper



Laisser les vêtements à l'extérieur et les laver avant de les porter à nouveau

Figure 1. Educational posters distributed to the education-only and education and equipment distribution communities.

This research brief outlines research conducted by Duke University, Colorado State University, and Michigan State University. It examines the efficacy of an education and equipment distribution intervention on increasing knowledge of mercury dangers and use of retorts. It specifically pairs a graphics based, culturally appropriate, and community-oriented educational training with distribution of locally produced and affordable retorts. More detailed information can be found in the full publication (with French translation available in the Supporting Information) at: <https://www.sciencedirect.com/science/article/pii/S2666791623000234#appsec1>.

METHODS

We analyzed the effects of education and retort (mercury-capture devices) distribution through pre- and post-intervention surveys in nine Senegalese mining communities. Three communities were controls and received no intervention: Bantako, Gamba-Gamba, and Tomboronkoto. Three communities received only the educational training: Kharahenna, Koliya, and Ngary. And three communities received both the educational training and the distribution of retorts: Tenkoto, Mamakhono, and Sambranbougou. We conducted pre- and post-surveys in these villages to determine the impact of the intervention on mercury knowledge and retort use.

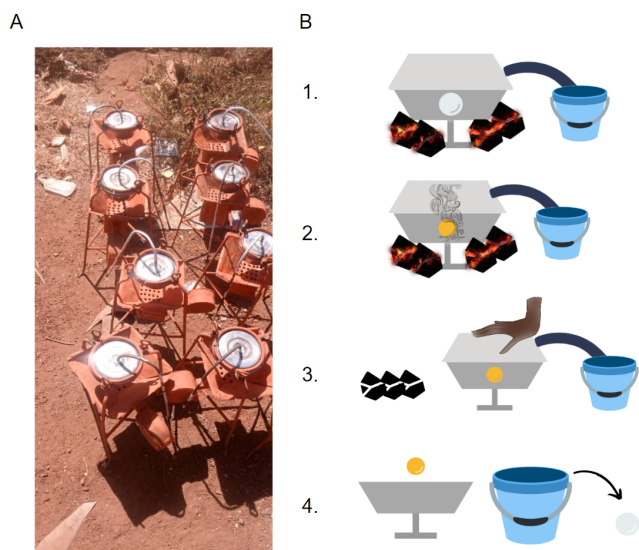


Figure 2. A) Retorts as distributed to the miners in the education and equipment intervention group. Retorts were made with locally available equipment by a local metal worker using a previously optimized design but modified with miner feedback. B) Diagram of how retorts operate, featuring a mercury vapor condensing tub that feeds into a water receptacle, allowing the mercury to be collected rather than vaporized into the air. 1) The mercury-gold amalgam is placed in the retort with the lid on and heated. 2) The mercury burns off and feeds through the mercury condensing tube, so that the mercury drops into the water, leaving gold behind. 3) Miners remove the retort from heat and wait for it to cool down. 4) The gold left behind can be retrieved as well as the mercury collected in the water receptacle.

Educational sessions were conducted in local languages using simple graphics by trusted community members. Visuals were created with feedback from local Senegalese collaborators to ensure cultural appropriateness (Figure 1). Trainers were trained on the information so that they could present the information to miners and community members and answer questions respondents asked. Trainers were paid a per diem for attending this training. Trainers then led at least ten formal educational sessions and additional informal educational sessions in each education-only and education and equipment distribution village from December 2020 to May 2021. All educational

sessions were conducted in local languages via both formal (i.e., sessions designed specifically to discuss these topics) and informal (e.g., conversations occurring over tea) meetings. These sessions emphasized the dangers of mercury and the use of retorts and personal protective equipment to reduce mercury emissions and exposure. Village notables (e.g., village chiefs, imams, elected officials), miners, vendors, women's groups, and youth were all targeted for the educational sessions. Information was also spread through local radio. Trainings were carried out over the course of five months, from December 2020 to May 2021.

In addition to education, education and equipment distribution villages received equipment distribution to local stores, making the items available for purchase. The goal was to increase access to equipment that can reduce mercury exposure, while still requiring people to invest monetarily in the items, thereby reducing reliance on outside organizations for continuity of this program. Retorts were made using locally available equipment by a local metal worker using a design previously optimized for mercury capture by Peace Corps Senegal Volunteers working with the Lycée Technique Industriel et Minière de Kedougou (Figure 2). The design emphasized the needs of miners and incorporated their feedback. The first set of equipment (30 retorts, 33 sets of latex gloves, 200 surgical face masks) was provided free of charge to stores, and they purchased equipment restock with the profits from selling the first set. Store owners were put in direct contact with the local metal worker so that they could order additional retorts. Retorts sold for 15,000 CFA, gloves for 2,000 CFA, and masks for 200 CFA.

RESULTS

Background Statistics

71% of respondents reported mining as their main income source and 88% of miners engaged in mining

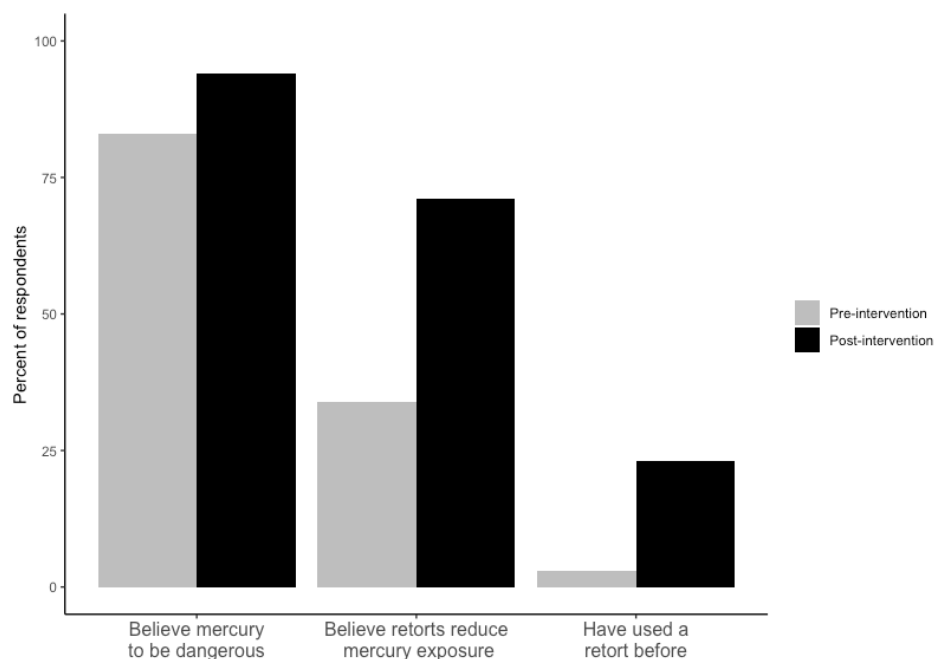


Figure 3. Percent of respondents in the pre- and post-intervention survey who A) Believe mercury to be dangerous, B) Believe retorts reduce mercury exposure, and C) Have used a retort before.

for at least 30 hours per week, with an average of 39 hours. 90% of those currently mining expect to continue mining for at least 1-3 years more, and 73% of the miners mine all year. 75% of respondents have burned the mercury-gold amalgam themselves.

The intervention was effective at increasing people's knowledge about the dangers of mercury and benefits of retort use.

After the educational sessions and equipment distributions in three villages, nearly all respondents (94%) from all three groups across the nine villages reported mercury exposure as dangerous (compared to 83% pre-intervention). All groups also increased their knowledge about retorts; nearly three-quarters of respondents in the education-only group believed retorts could reduce mercury exposure at least a little after the intervention (compared to 34% pre-intervention).

This intervention was successful because the educational sessions were led by trusted community members, which ensured that information was presented in a culturally-appropriate manner and that attendees felt comfortable participating and asking questions. We also sought out the support of village chiefs, imams, and community leaders, which further emphasized the importance of this work to miners and community members. Finally, we recognized that the duration of educational sessions is important, and we carried out the educational sessions over the course of six months rather than just a few days.

The intervention was effective at increasing miner's use of retorts when burning mercury-gold amalgams.

As a result of the intervention, 23% of respondents in the education and equipment distribution groups have used a retort to burn the Hg-gold amalgam (compared to 3% pre-intervention) (Figure 3), 10%

use a retort at least sometimes (compared to 2% pre-intervention), and 5% frequently and/or always use a retort (compared to 0% pre-intervention).

The efficacy of our intervention was in part due to our incorporation of feedback from miners regarding the retort design. Retorts were constructed with a clear lid so that miners could see the entire process, and all materials were sourced from local stores so they could easily be constructed and repaired. As a result, miners learned to trust this new version of the retorts, leading to our first distribution of retorts selling quickly and additional orders immediately placed. Miners also provided continuous feedback to the metalworker regarding changes in retort design to fit their needs, and the metalworker was able to incorporate these suggestions.

These results also strongly suggest the importance of pairing education with access to equipment to generate action, as knowledge alone (i.e., the education-only group) was much less effective at increasing retort use. It was the physical distribution of retorts within local stores that was important for this behavior change.

The impacts of the intervention extended beyond those receiving the educational trainings.

While we expected to find that the two groups receiving education would have increased knowledge, we were surprised to find that the control group exhibited similar patterns. We believe these findings are a result of social interaction and movement of people between villages. It is likely that new knowledge gained during the educational sessions was shared accordingly.

CONCLUSION

This is the first study to look at the effects of combined educational sessions and increased access to retorts to reduce gold miners' exposure to mercury. It builds on approaches first identified in community

meetings during which we asked miners, village chiefs, imams, and other local leaders to propose solutions to reduce their mercury exposure. Through this bottom-up approach, we collectively identified increased education and access to cleaner technologies as potential solutions. We then worked with local leaders to identify the best mechanisms for delivering this information and equipment.

ASGM is an important livelihood for many people in Senegal and throughout the world. Given the dangers of mercury toxicity and the high exposure of miners and ASGM communities, it is imperative that we find and implement solutions to reduce their exposure. This study provides one mechanism by which this can be effectively achieved. Our results indicate that the graphics-based and community-oriented educational approach accompanied by increased access to retorts provides a strong foundation for reducing mercury emissions and exposure to ASGM communities.

We have built momentum for these educational sessions and equipment distributions over the course of one year and have seen a positive reaction. Trainers are interested in continuing this work, and mining communities are embracing these opportunities, but we must continue to invest in this program rather than declaring it complete after the funding cycle ends. We know from previous studies that education and practical hands-on training must be paired together. Here we show that education can increase knowledge, but increased access to best practice technologies is vital to effective behavior change.

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