2014

Gold Miners' Knowledge, Attitudes & Practices with regard to Mercury

A study in four small-scale gold mining regions in Suriname

WWF

GOMIAM
SMALL SCALE GOLD MINING IN THE AMAZON

Social Solutions

Gold Miners' Knowledge, Attitudes & Practices with regard to Mercury

A study in four small-scale gold mining regions in Suriname

October 2014 | Final Report

Produced for:

The GOMIAM research network
Keizersgracht 395-397
1016 EK Amsterdam
the Netherlands

Phone: +31 20 525 3498
E-mail: info@gomiam.org

&

WWF-Guianas
Henck Arronstraat 63 Suite E
Paramaribo, Suriname

Phone: +597 422 357
E-mail: info@wwf.sr

Produced by:

Social Solutions
Siriusstraat 14, Elizabethshof
Paramaribo, Suriname
Tel: (597) 457885
www.social-solutions.net

Authors:
Celine Duijves en Marieke Heemskerk
Email: celineduijves@hotmail.com
Email: mheemskerk@yahoo.com

ACKNOWLEDGEMENTS

Conducting this study would not have been possible without the support and collaboration of many organizations and individuals. The study is a joint effort between WWF-Guianas and the Small-Scale Gold Mining in the Amazon (GOMIAM) research initiative.

Specifically, we acknowledge the following local counterparts, stakeholders and partners who contributed at various stages of the study:

- Dr. Marjo de Theije, Project Coordinator GOMIAM, Netherlands
- Dr. Mark Wright, Conservation Director, WWF Guianas, Suriname
- Mr. Laurens Gomes, Country Manager for Suriname, WWF Guianas, Suriname
- Ms. Sofie Ruysschaert, Biodiversity officer WWF Guianas, Suriname
- Mr. Gerold Dompig, Head of the management team of the Commission OGS
- Mr. Berard Paansa, Chief exploration and geology GMD Geology and Mines Department (GMD)
- Ms. Farzia Hausil, Staff legal department, National Institute of Environment and Development (NIMOS)
- Mr. John Courtar, Head Medical Bureau OSH and policy advisor, Ministry of Labour, Technological Development and Environment (ATM)
- Mr. Chris Healy, Anthropologist and Commission OGS consultant

Our special gratitude goes to the numerous small-scale gold miners who shared their time and information, as well as food and lodging arrangements. We also wish to thank the teams of surveyors who worked irregular hours and under often difficult conditions far from home, and the data entry assistant for her meticulous work. Images were taken by the authors, unless indicated otherwise.

GOMIAM is funded by WOTRO, research for development, through the CoCooN facility. CoCooN is a knowledge, research and innovation programme on Conflict and Cooperation over Natural Resources in developing countries. WOTRO is funded by the Directorate General of Development Cooperation (DGIS) of the Ministry of Foreign Affairs of the Netherlands and the Netherlands Organisation for Scientific Research (NWO). We are grateful to WWF-Guianas and GOMIAM for providing financial support to make this study possible.

Opinions expressed in this report are those of the authors and do not necessarily reflect the views of WWF, GOMIAM, or other institutions the authors are affiliated with. The authors are responsible for all errors in translation and interpretation.

ABBREVIATIONS & FOREIGN WORDS

ADEK	Anton de Kom University
ATM	(Ministerie van) Arbeid, Technologische ontwikkeling en Milieu (Ministry of) Labor, Technological development and Environment
Baté	Gold pan
BOG	Bureau Public Health - *Bureau Openbare Gezondheidszorg*
BRA	Brazilian Portuguese
Cadinho(BRA)	Retort
CHM	Curaçaose Handel Maatschappij
Currutela	Gold miners' community/population concentration in the mining area
Deci	Decigram (0.1 gram)
Despescar	Gathering/washing of the concentrate that has been captured in the sluice box
Dono de máquina	Equipment owner/mine boss
EPA	Environmental Protection Agency
g	gram
Garimpeiro (BRA)	(Brazilian) small-scale gold miner
Garimpo (BRA)	(Brazilian) small-scale gold mining area
GMD	*Geologisch Mijnbouwkundige Dienst* - Geology and Mining Department
GMP	Global Mercury Project
GOMIAM	Small-scale Gold Mining in the Amazon (research network)
Hg	Mercury (Chemical notation)
ibid.	ibidem – meaning: in the same place
IISD	International Institute for Sustainable Development
Kg	Kilogram
KAP	Knowledge, Attitudes, Practices
L	Liter
Mg	Mega gram (metric tonne)
NGO	Non Governmental Organization
NIMOS	Nationaal Instituut voor Milieu en Ontwikkeling
N	Number (sample size)
OGS	*Ordening Goudsector* - Regulation of the gold sector
OSH	Occupational Safety and Health
PAHO	Pan American Health Organization
ppm	Parts per million (1 ppm=1 µg/g)
SEMIF	Suriname Environmental and Mining Foundation
SPSS	Statistical Package For Social Sciences
SUR	Suriname
µg/g	microgram per gram
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
US	United States
USD	United States Dollar
VCB	Volks Crediet Bank
WHO	World Health Organization
WWF	World Wide Fund for Nature *or* World Wildlife Fund (US and Canada)

SUMMARY

Introduction: This report presents the results of a Knowledge, Attitudes and Practices (KAP) study among small-scale gold miners in Suriname. The study was commissioned and funded by the research network on small-scale GOld MIning in the AMazon (GOMIAM) and WWF Guianas. Its primary objectives are to document the movement of mercury in the small-scale gold mining cycle; analyze gold miners' knowledge about mercury and its health effects; and assess gold miners' attitudes with regard to mercury use and the possible elimination of mercury from the mining process.

Methods: Secondary data was collected by reviewing existing information about mercury use and contamination related to small-scale gold mining in Suriname and in the Guiana shield region in general. Survey interviews were conducted with gold miners in three small-scale gold mining regions: Matawai (Pikin Saramacca, Mindrineti), Brokopondo north of the lake, and Merian/Tumatu. In addition, qualitative interviews were conducted with key professionals and local experts.

Background: In Suriname, the import of mercury requires a license, but there are no additional laws that explicitly mention mercury. Nevertheless, existing laws (Labour Law, Mining Decree) do provide regulations that can be used to manage the use of mercury and reduce its adverse health effects. Within the government, responsibilities and knowledge about mercury are fragmented among ministries and departments, which obstructs effective policy making and implementation with regard to mercury.

Small-scale gold miners are in contact with mercury in different stages of the mining process, notably amalgamation, separation of the amalgam, removal of excess mercury and burning the amalgam. Exposure to mercury may cause a wide range of symptoms including chemical bronchiolitis and pneumonitis (from inhalation), and damage to the nervous, digestive and immune systems, as well as the lungs and kidneys. Mercury poisoning can usually not or only partially be treated.

Since the late 1990s, governmental institutions (GMD, OGS) and NGOs (WWF, PAHO) have executed mercury awareness campaigns among gold miners in Suriname. Challenges in motivating gold miners to reduce mercury use include: lack of mining concession titles for small-scale miners, limited awareness, mobility of gold miners, minimal monitoring and control, and the expenses of equipment for mercury-free mining.

Results: The cleaned survey sample counted 115 Surinamers, 58 Brazilians, and 5 Guyanese. More than half of respondents had bought mercury in Paramaribo the last time they had bought it, mostly in the streets. About one third of the gold miners had bought mercury in the mining areas, most often in a shop. Virtually all gold miners (97.8%) admitted they used mercury in the mining process. The amount and method of application is dictated by: (a) habit/experience; (b) perceived quantity of gold; (c) perceived depletion of the deposit; (d) previous work and use of mercury at the location; and (e) observation of the coarseness of gold (i.e. grain size). Almost three quarters (71.2%) of interviewed gold miners reported whole ore amalgamation, where mercury was always or sometimes applied to the unprocessed ore. It is relatively less common to place mercury in the sluice box during the mining

process (35.0% always or sometimes). Gold miners typically apply mercury in the concentration phase (73% always or sometimes).

In burning the amalgam, gold miners did not show a strong preference for burning either on a wood fire or with a burner. Almost two-thirds of surveyed gold miners (64.9%; N_{total}=168) reported covering the baté with large leaves to prevent the vapour from escaping into the air. Few gold miners burn the amalgam inside the cooking and/or sleeping hut. Even though 65.7 percent of gold miners had heard of a retort, only 8.8 percent reported "always" using this device for burning the gold-mercury amalgam. Of those individuals who had experience with a retort, 82.8 percent reported that it (had) worked very well. Among those miners who had heard of a retort and were not using one at the moment, the main reasons for not using one were that there was none at the camp and that it took too long to burn the gold, which was felt as a security risk. The fact that gold burned in a retort is hard to break and divide was also mentioned as a disadvantage.

Eighty-two percent of gold miners in teams working with mercury personally handled mercury. Almost all miners in this group said they had skin contact when doing so; when squeezing excess mercury from the amalgam (72.4%), washing the sluice box (56.1%), or when throwing mercury on the unprocessed material (51.2%; N_{total}=123). More than half of the surveyed miners indicated that they were concerned about contact with mercury (59.9%; N_{total}=177), primarily because of the adverse health effects. Reasons for not being worried about mercury were mostly related to nonchalance, disbelief in the risks, and trust in the efficiency of protection and one's own strength. One out of every five gold miners indicated that they did not protect themselves against contact with mercury (21.1%; N_{total}=166[1]). Whereas virtually no gold miners prevented skin contact with mercury, they generally did make a conscious effort to limit contact with the fumes. They mostly covered their nose and mouth with a cloth (41.6%) a nose cap/mask (10.2%) or the hands (0.6%; N_{total}=166). Others stayed at a "safe" distance and/or made sure to be out of the wind direction when burning the amalgam.

Nearly two out of every five gold miners had never received information about mercury (39.3%; N_{total}=178). Gold miners who had received information, had mostly received it from the media (24.7%) or friends and colleagues (23.0%; N_{total}=178). Awareness activities from the government and NGOs have been little effective in reaching the majority of gold miners. Topics that gold miners mostly wanted to learn more about included the health effects (34.3%); how to use mercury wisely (21.9%); the dangers and impact in general (16.3%); and how to work without mercury (10.1%; N_{total}=178).

When asked how mercury might enter the human body gold miners most often mentioned inhalation of vapours (55.6%), followed by the consumption of fish (16.4%) and vapour entering the pores (7.3%). With regard to the fish that tend to have relatively higher mercury levels, most people among those who provided an answer correctly named types of piscivores- though not necessarily for the correct reason. Generally knowledge about the health effects of mercury was suboptimal. One third of gold miners could not name any venue of mercury contamination in people; half of surveyed gold miners did not know what fish generally have relatively higher mercury content; and 88.8 percent was unable to name

[1] twelve persons said they did not have any contact with mercury and thence the question did not apply to them

any of the effects that can be caused by mercury poisoning (N_{total}=178). Furthermore, 71.3 percent of gold miners reported they did not know how mercury can be removed from the body, and those who did provide an answer mostly had it wrong (N_{total}=178). Gold miners also had a very poor understanding of the dispersion of mercury in the natural environment, and did not think that their use of mercury could affect people in locations beyond the mining area. More than a third of small-scale gold miners did not believe that the health of children could be affected by the use of mercury in a nearby mining area (35.4%; N_{total}=178).

Two thirds of small scale gold miners -relatively more migrants- indicated that in their opinion it was possible to work without mercury (63.5%;N_{total}=178). In the case of a ban on mercury in small-scale gold mining, the largest group of gold miners would just continue without mercury. Others expected that gold miners would use mercury clandestinely (18%;N_{total}=178). As compared to migrant miners, Suriname gold miners were more likely to expect problems and voiced the opinion that the government was responsible for finding a solution.

Conclusions and Recommendations: The researchers conclude that in Suriname, excessive and uncontrolled use and spillage of mercury in gold mining is facilitated by (a) omissions in the regulatory framework, (b) the accessibility of mercury, (c) the widespread practice of whole ore amalgamation, (d) low mercury recycling and (e) suboptimal understanding and awareness of mercury related health risks. The authors pose that improved knowledge and awareness activities aimed at reducing mercury consumption will likely have more impact if they are part of an integrated multi-sectoral policy intervention.

It is recommended that the Minamata Convention is ratified and used to guide the development of a widely supported action plan to phase out mercury. The KAP study advocates working towards a total ban on mercury use in small-scale gold mining in two stages. As a first immediate step, adequate authorities should design, implement and enforce regulations aimed at the reduction of mercury consumption. Two main ways to achieve this would be to stop whole ore amalgamation and increase recycling, among others by obliging use of a retort. The longer term goal, however, should be the elimination of mercury from the gold mining process. Both equipment owners and concessionaries are to be held responsible for mercury use in their operations and on their concessions. In order to succeed, compliance must be controlled and monitored through active government presence in all mining areas.

The researchers also recommend the delivery of easily digestible and accurate information about the main ways that mercury affects people, the health effects of mercury, and measures to reduce mercury consumption as part of an integrated policy on mercury use in the small-scale gold mining sector. Both GMD and Commission OGS staff should be trained in the specifics of (reduced) mercury use and its effects, and proactively disperse such information among small-scale gold miners. The researchers also recommend learning from and collaboration with international (e.g. to Global Mercury Project) and national (e.g. Malaria Program) programs. The listed actions require an integrated approach in line with the Minamata roadmap developed by NIMOS, and supported by awareness activities. Relatively small adjustments in the regulatory framework and installation of the national mercury platform can provide a strong policy basis to support the mentioned efforts.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 A study on small-scale gold miners and mercury

This report presents the results of a Knowledge, Attitudes and Practices (KAP) study among small-scale gold miners in Suriname. The study was commissioned by the research network on small-scale GOld MIning in the AMazon (GOMIAM) and WWF Guianas.

A study on how gold miners in Suriname use and think about mercury is important because the Guiana Shield eco-region[2], which Suriname is part of, may possess the world's highest percentage of intact tropical rain forest, with some 80-90 percent still in pristine condition. It is the home of a large number of Indigenous ethnic groups and numerous rare and endemic animal and plant species. The health and future existence of this unique ecosystem is increasingly threatened by uncontrolled small-scale gold mining activities. An estimated 100,000 persons may be mining for gold in the Guiana shield eco-region, employing a variety of methods and mining techniques. They pan for gold; dredge rivers; manually dig up materials with pick-axes and shovels; work with hydraulic systems; use mechanized crushers; and employ large earth moving equipment.

Virtually all small-scale gold miners use mercury to separate the gold from other soil particles, typically without adequate personal protection or regard for release of this toxic substance into the air, soils or waterways. It has been estimated that miners use approximately two units of mercury to capture one unit of gold (Telmer and Veiga 2009). However, based on the experience in other Amazon countries, observations in Suriname gold mines and extrapolations, Suriname's Commission Regulation Gold Sector (*Ordening Goudsector - OGS*) has estimated that gold miners in Suriname may use as much as five units of mercury for every unit of gold extracted (G. Dompig, head of the management team of OGS; pers. com. 1 Aug. 2014). In fact, when whole ore processing takes place, which is rather common in Suriname as we will see, it has been found that between three and fifty units of mercury are consumed to produce one unit of gold, with an average of around five (Telmer and Veiga 2009) - in agreement with the OGS estimate. WWF Guianas has estimated mercury consumption by small-scale gold miners in Suriname at 7.5 Mg/yr (Vieira 2008, quoted in Telmer and Veiga 2009).

Of the mercury used in gold mining operations, approximately 55 percent is lost to the atmosphere and 45 percent is lost to streams (Pfeiffer and Lacerda 1988, cited in Ouboter at al. 2012). Given that approximately 22 tonnes of gold from small mines was legally exported in 2013 (Deviezencommissie 2014), and that mercury recycling is not common practice in Suriname (see Ch. 4), at 44 tonnes of mercury –and possibly much more- may have been released in the natural environment in that year. These figures are worrisome because gold mining-induced mercury contamination of the environment has detrimental effects on human health (See chapter 2).

[2] The Guiana shield ecoregion covers Guyana, Suriname and French Guiana, as well as parts of Colombia, Venezuela and Brazil.

Apart from a 2004 assessment for WWF Guianas, no more systematic studies on gold miners' knowledge and perceptions about mercury use have been conducted in Suriname. Neither are we aware of the existence of empirical data about mercury use behaviours and practices in Suriname. We argue that efforts to motivate gold miners to use less or no mercury in the gold mining process will have more chances to succeed if they are based on empirical data. Hence it is important to understand how gold miners decide how much mercury to use and in what stages of the mining process. Do small-scale gold miners understand what mercury does to the body and how one can recognize mercury intoxication? Are miners aware of impacts of mercury on the non-mining community, such as downstream riverside populations? Are environmental and technological changes affecting mercury use? And how do knowledge and practices differ between Suriname and migrant gold miners, and between miners who differ on the basis of age or years of mining experience? The present study aims to answers these and related questions.

1.2 Study objectives

In light of the above stated concerns and in an effort to address existing paucities in information, the present KAP study about mercury use among small-scale gold miners in Suriname has the following objectives:

- Compile existing knowledge about mercury use among small-scale gold miners and make an inventory of lessons learned from efforts to motive small-scale gold miners to reduce or eliminate the use of mercury; in the Guiana shield eco-region in general and in Suriname in particular;
- Analyze gold miners' knowledge and attitudes about mercury, the effects thereof on human health, and the possible elimination of mercury from the mining process
- Document current practices with regard to the use of mercury among small-scale gold miners in Suriname, paying particular attention to the movement of mercury in the mining cycle (e.g. acquisition, place and moment of use, share recaptured, and likely places and moments of loss);
- Analyze differences in mercury-related knowledge, attitudes and practices among gold miners who differ in nationality, socioeconomic background, and age.

These objectives were specified in the TOR and in the work plan that was submitted to WWF-Guianas and GOMIAM prior to the fieldwork.

1.3 Commissioning parties and beneficiaries

This study was commissioned by WWF Guianas and the Amazon wide research program GOMIAM. GOMIAM stands for "Small-scale gold mining and social conflict in the Amazon: Comparing states, environments, local populations and miners in Bolivia, Brazil, Colombia, Peru and Suriname". The GOMIAM research project is funded by WOTRO, Science for Development, a subdivision of the Netherlands Organisation for Scientific Research. Its principle objective is to develop a comparative understanding of socio-political and environmental conflicts related to small scale gold mining in the Amazon, and contribute to their possible solution.

WWF Guianas is the regional office of the international conservation organization WWF, and executes projects in Guyana, Suriname and French Guiana. The present study aligns with WWF Guianas' 2012-2016 program, supporting Strategy III "Promoting responsible small-scale gold mining", and with WWF Guianas' support to the Government of Suriname on developing an action plan to phase out mercury use in the gold mining sector. The consultant poses that program support aimed at promoting mercury-free mining is likely more effective if it builds upon present levels of miners' knowledge and takes current perceptions and behaviours into account.

The proposed KAP study is timely because the Government of Suriname is working on a national mercury strategy, which outlines the steps to be followed for compliance with the Minamata Convention guidelines (See Ch. 3). The information collected through this study may provide input into the development and execution of a national mercury strategy.

The collected information also will be the basis for the development of mercury awareness materials for small-scale gold miners that address actual gaps in knowledge and aim to eliminate harmful practices. These materials will be developed with continued support from GOMIAM and WWF Guianas.

1.4 Outline of the report

This **first, introductory chapter** provided a brief introduction to mercury use among small-scale gold miners, and the relevance of the study. It also laid out the study objectives, and provided information about the commissioning party and beneficiaries.

In the following pages we will proceed as follows:

Chapter 2 describes the methods to collect and analyse data. This chapter also describes the survey design and sample, and presents a map of the study regions in Suriname.

Chapter 3 contains background information about the use of mercury among small-scale gold miners in Suriname and neighbouring countries, based on secondary information and interviews with Suriname professionals. The chapter contains information about the regulatory framework and policies; existing knowledge about small-scale gold miners and mercury use; a summary of earlier research on mining-induced mercury contamination and gold miners' mercury knowledge and awareness; and a review of lessons learned from efforts to motivate small-scale gold miners to reduce or eliminate mercury use.

Chapter 4 presents the field study results. It discusses:

- Study population characteristics
- Mercury use cycle (acquisition, amalgamation, burning), including knowledge and use of retorts
- Forms of contact with mercury and related risk perceptions
- Exposure to awareness raising activities
- Knowledge of the environmental and health effects of mercury
- The way forward; knowledge and perceptions of mercury free mining

Where useful, results are illustrated with tables and figures.

The conclusions and recommendations are laid out in **Chapter 5.** In this section we describe the conditions in Suriname that allow for uncontrolled excessive mercury consumption and identify main areas where realistically improvement is possible and necessary. In the recommendations we provide more specific guidelines for the reduction of mercury use in small-scale gold mining areas in Suriname, in line with NIMOS' roadmap to prepare Suriname for the Minamata Convention. We also suggest responsible departments and organizations.

The annexes include a sheet with facts and figures on mercury contamination in Suriname and its neighbouring countries (Annex I), and the survey instrument (Annex II).

2. METHODS

2.1 Secondary data collection

The consultant reviewed existing information about mercury use and contamination related to small-scale gold mining in Suriname and in the wider Guiana shield region. Sources of information included published academic papers, scientific reports, and studies and field reports from local, regional and international organizations including WWF, UNDP, UNIDO, the Anton de Kom University of Paramaribo (ADEK), Regulation of the Gold Sector (*Ordening Goud Sector - OGS*), the Ministry of Labour, Technological Development and Environment (*Arbeid, Technologische Ontwikkeling en Milieu - ATM*), and the National Institute for Environment and Development in Suriname (*Nationaal Instituut voor Milieu en Ontwikkeling in Suriname* -NIMOS).

This information served to document what is known about the use of mercury by small-scale gold miners in the region; miners' knowledge and perceptions about mercury use; measured and observed health effects of mercury in mining populations and river communities; and mercury contamination of fish and natural elements including water, soils, river sediments and mine tailings.

2.2 Field study locations

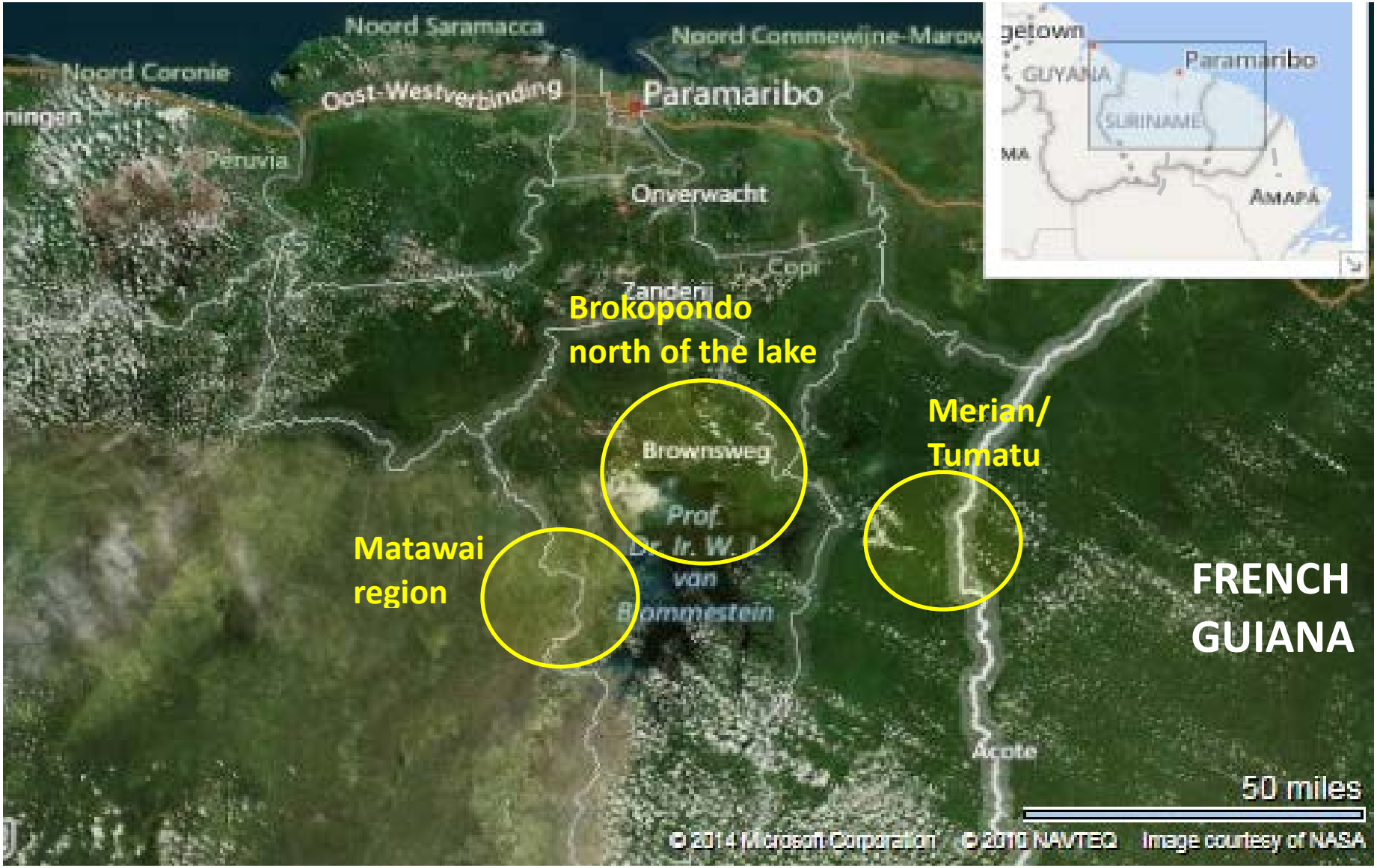
Field work was carried out in three small-scale gold mining regions, as listed in table 1 and depicted in Figure 1. The table also provides the number of survey interviews completed per mining location.

Table 1. Fieldwork locations with number of survey respondents per location

Region name	Gold field / *garimpo*	# surveys*
Matawai region: Pikin Saramacca and Mindrineti	Pikin Saramacca	23
	Sarafina	3
	KM 34	2
	KM 16	7
	OGS working area 1 (KM 14)	4
	Krabudoin	4
Brokopondo, north of the lake	Bewojo (Klaaskreek)	15
	Roma (Nw. Koffiekamp)	43
	Bisumbar concession	8
	Balengsula	8
	Boslanti	13
Merian/Tumatu	Tumatu	16
	Baixão do Tren	20
	Kawina	12
Total		**178**

*Surveys that were removed from the sample because of inconsistencies are not included

Figure 1. Map of Suriname with the mining regions. Field work locations are marked with yellow circles



Selection criteria for inclusion of these locations were:

- Diversity of gold mining populations (locals and migrants)
- Previous WWF/GMD/OGS mercury awareness activities in some of the locations
- Relative accessibility; i.e. travel times and expenses

Given their geographic range and population diversity, we are confident that the small-scale gold mining population in the selected fieldwork areas provided a good representation of the mining population in Suriname at large.

2.3 Primary data collection methods

2.3.1 Survey interviews with small-scale gold miners

Survey interviews with small-scale gold miners contained mostly pre-coded, closed ended questions. The questions focused on:

Mercury use cycle in mining: where do gold miners buy mercury? Where in the mining cycle do miners apply mercury? Is mercury lost or recycled?

Amalgamation and separation: When and how do people mix mercury and gold? Where and how do miners burn the mercury-gold amalgam? What measures are taken to prevent mercury from spilling into the environment?

Knowledge: What do gold miners know about the effects of mercury contamination? What do miners know about mining methods to recycle or eliminate mercury in the mining process?

Perceptions: Do miners believe that mercury is dangerous; do they worry about health effects? How do gold miners protect themselves against contact with mercury? Do they believe working without mercury is possible?

2.3.2 Local expert interviews

Local experts are people who live and/or work in the mining area and possess, based on their personal experience, key knowledge about behavioural patterns in this area. They may be experienced equipment owners, supervisors, security personnel or others with substantial working experience in a certain area.

Local expert interviews contained open ended questions about the same topics as listed in 3.3.1. In this case, the questions ask about general patterns in knowledge, attitudes and practices in the mining area at large rather than about personal behaviour. Two local expert interviews were conducted; one with a long-term Suriname gold miner and one with a Brazilian equipment owner who had been working in gold mining since the late 1970s. .

2.3.3 Key professional interviews

Key professionals are people with a formal educational and professional background in mining, environment and/or government regulation. These persons include government regulators, staff of relevant government offices, and medical specialists.

The consultant conducted qualitative interviews with mostly open-ended questions with six key professionals. Questions focussed on the person's particular knowledge and experience, and served to obtain a broader and more in-depth understanding of gold miners' use of mercury, related environmental health problems, and possible interventions to reduce the release of mercury into the environment.

2.4 Survey sample and sampling strategy

Taking a random sample of persons working and living in the gold mining areas is nearly impossible because there is no public registry of gold miners with their working location and their work is typically informal. Moreover, gold miners travel around within the mining area between their working location, the miners' camp where they sleep, and the miners' communities or *currutela (*Bra.) where they buy goods and seek entertainment. Furthermore, gold miners move around between mining areas when the prospects for finding gold are better elsewhere.

In order to reduce bias, the researchers maximized spread of the interview population by interviewing no more than two persons per mining team in the selected mining areas. We considered as one team a group of persons working with one set-up of machinery working one deposit together. The smallest team consisted of two persons working with a small hydraulic machine in a system locally known as *sumajé*; the largest teams had six to eight persons. In some cases, two teams would share one camp area.

In some places such as Roma (Nw. Koffiekamp), the gold miners stayed in huts standing next to one another. In these places, the surveyors could go from mining team to mining team by foot. In other places, such as Tumatu and Pikin Saramacca, the gold mining camps were located on quite a distance from one another. In these locations, the surveyors travelled by car from miners' camp to miners' camp. In addition, miners were interviewed upon encounter on the road, and at hang-out spots such as bars, stores and brothels. Also at these locations the surveyors made an effort to ensure that no more than 2 gold miners per mining team were interviewed.

The inclusion criteria for participation in the survey were:

- The person must be actively involved in actual gold mining activities; as an equipment owner, a camp manager or supervisor, or mine labourer (hence no service providers such as shop owners and cooks).
- The person must be 16 years of age or older

A total of 186 small-scale gold miners were interviewed, of whom 117 Surinamers, 64 Brazilians and 5 Guyanese. Eight survey forms had to be removed from the sample because the answers were

inconsistent and/or because it was obvious that they were not telling the truth. For example, in one case a worker told the interviewer that the team was not using mercury, but the equipment owner of that same team reported that they did use mercury and specified how. Hence we removed the interview with the worker from the sample.

Characteristics of the survey sample are described in section 4.1.

2.5 Protection of Human Subjects and Ethical Review

Research procedures adhered to professional ethical standards for anthropological research. Prior to conducting a survey interview, the interviewee was approached in an unobtrusive manner. The surveyor introduced him or herself and explained the purpose of the research. The surveyors also explained the interviewee that participation in the research was voluntary and anonymous. Interviewees were compensated for their time with a mobile phone recharge card.

Several people, particularly migrant miners, were at first hesitant to provide honest information about their use of mercury to the surveyors because they assumed that it was illegal and that its use could bring them in trouble with law enforcement. The interviewers tried make the interviewees feel at ease, and take away this concern by explaining that the questions were only asked for the purpose of research and gaining understanding of the situation in the mining areas. It was also laid out that the data would not be recorded in a way that could be linked to individuals and that one of the aims of the study was to eventually bring better information to the gold miners.

Names of study participants have not been recorded. Information provided to the survey team by the gold miners has been treated confidentially, and the survey data are presented in an aggravated manner.

2.6 Data analysis

Survey data were entered in the statistical software package SPSS. The data were cleaned and cross-checked prior to and during the analysis. Unreliable and/or inconsistent survey forms were removed from the sample.

Data were analyzed using univariate and bivariate statistics. The results have been presented in text, tables and figures. Where applicable, additional information provided by surveyed gold miners, informal experts, and other consulted stakeholders was added.

2.7 Research team

The research team was headed by two anthropologists, who jointly designed the research protocol and instruments. During the field research, the lead researchers relied on the assistance of five survey assistants, who were selected on the basis of their previous experiences with similar survey work; their language skills; and/or their familiarity with the research localities. The survey assistants formed sub-groups to visit the various survey sites, based on their knowledge of these locations and their language

skills. At every field visit, at least one of the lead researches went along to supervise the survey work. A data entry assistant was hired for entry of the survey data.

2.8 Limitations and assumptions

The proposed KAP study is subject to several limitations:

- **Sampling.** As explained above, it is difficult to take a random sample of migrants who work in the mining areas. Because migrants were interviewed 'upon encounter' in target locations, the results cannot be extrapolated to the population at large. Nevertheless, by sampling a diverse group of gold miners we believe that the results are representative for the Suriname gold mining population at large.
- **Travel expenses in time and money**. Travel to and within the mining areas are expensive and takes a lot of time because of the dispersion of the mining camps. Hence the team had to select a limited number of mining locations. The consultant is confident that the selection of locations is representative of the mining communities in Suriname.

The researchers also rely on the following assumptions

- **Representativeness.** The researchers assume that by targeting gold miners of different subgroups in terms of nationality, mining experience and age, the study provides a fairly accurate representation of the gold mining population, their habits, their opinions and their attitudes.
- **Reliability**. We also assume that interviewees answered to the questions to their best ability and in a truthful manner. In cases where the reliability of a respondent was questionable, the survey form was excluded from the analysis.

3. BACKGROUND

3.1 Regulatory and policy framework

In the government regulation Decision Negative List (*Besluit Negatieve Lijst 2003*; S.B. 2003 no. 74), which forms part of the law on the transportation of goods (*Wet Goederenverkeer*;S.B. 2003 no. 58), mercury is listed with the items for which an import license is required. In January of 2013, the head of the department for Import, Export and Currency Control (*Invoer, Uitvoer en Deviezencontrole - IUD*) of the Ministry of Trade and Industries *(Handel en Industrie - HI*) stated that no single license for the import of mercury had been granted in the past 20 years (Dagblad Suriname 22-01-2013). This statement implies that most mercury used by gold miners enters the country illicitly.

Other than this regulation, there are no other legal instruments that specifically mention mercury (F. Hausil, Legal expert at NIMOS, pers. com. 30/06/2014). The Suriname legal framework contains no regulations about mercury sale; that is, about who is allowed to sell and whether or not a license is required. The criminal code dictates that it is punishable to "sell, offer for sale, deliver or hand out goods, knowing that the[se goods] are harmful to life or health, while omitting to mention their harmful character..." (Wetboek van Strafrecht, Art. 226). The criminal code also stipulates that it is unlawful to be responsible for "the sale, delivery or handing out of goods that are harmful for life or health, without the buyer or recipient being aware of the harmful character …" (Wetboek van Strafrecht, Art. 226) (F. Hausil, Legal expert at NIMOS, pers. com. 20/10/2014). From the above it appears that a taxicab driver who informally sells mercury to a gold miner on a street corner, and who tells the buyer that this mercury is dangerous, does not commit an illegal act. Also the gold miner who buys mercury acts within the boundaries of the law.

Furthermore, regulations of the Ministry of Agriculture, Animal Husbandry and Fisheries (*Landbouw, Veeteelt en Visserij*-LVV) stipulate that all fish needs to be controlled prior to sale, but not specifically on mercury content. In practice, the mercury content of fish for export is checked but it is unclear whether fish for the local market is also subject to control (ibid.).

The labour law states that employees may not be exposed to "harmful gasses and fumes". It would be possible to include specific requirements in the licenses for gold buyers who burn the gold, but so far the Currency Committee (Deviezencommissie), which extends the licenses, has not done so (ibid). The Medical Bureau Occupational Safety and Health (OSH) of the Ministry of ATM does measure emissions in and near gold buying centres, and plans to conduct bio-monitoring (J. Courtar, Head Medical Bureau OSH, Ministry of ATM. pers. com. 30 July 2014). On the basis of its findings, the department labour inspection of this same ministry can come into action where necessary.

The section on small-scale mining in the Mining Decree[3] (Ch. VII) does not specify any regulations with regard to environmental and human health. For the mining sector in general, the Decree stipulates that

[3] DECREET van 8 mei 1986, houdende algemene regelen omtrent de opsporing en ontginning van delfstoffen (Decreet Mijnbouw) (S.B. 1986 no. 28), S.B. 1997 no. 44.

mining must be carried out with "consideration for valid norms in terms of safety and health of employees specifically and of the community in general, as well as norms for the protection of ecosystems" but it does not define these norms. Mercury is not mentioned in this law. A draft State Decree (*Staatsbesluit*) to regulate mercury is awaiting approval by the Council of Ministers (M. Riedewald, sub-director Environment, Ministry of ATM, pers. com. July 30, 2014)[4].

Despite the absence of detailed regulations for the use of mercury in small-scale gold mining, both the Geology and Mining Department (*Geologisch Mijnbouwkundige Dienst - GMD*) and the governmental committee for Regulation of the Gold Sector (*Ordening Goudsector - OGS*) have executed activities with the aim to reduce the use of mercury in small-scale gold mining. These projects and the lessons derived from them are described in further detail in section 2.5. In addition, the state mining company Grassalco, which coordinates the small-scale gold mining activities at Maripaston, currently works with the International Institute for Sustainable Development (IISD) on an intervention to promote re-mining with mercury-free methods.

The Minamata Convention on Mercury (Draft text 19 January 2013) is a global treaty that contains guidelines and measures for signatory countries, with the aims to protect human health and the environment from the adverse effects of mercury. This Convention on Mercury places special emphasis on international regulation of the informal sector for artisanal and small-scale gold mining. The Minamata Convention was adopted in October of 2013 and has been signed and/or ratified by 100 countries, including all South American countries except for Suriname (UNEP 2014). The Suriname government is of the opinion that it needs to better prepare the country prior to signing the Convention. In this context, the National Institute for Environment and Development Suriname (*Nationaal Instituut voor Milieu en Ontwikkeling Suriname* – NIMOS) is finalizing a policy document for the government, with a roadmap (supported by WWF Guianas). It is foreseen that this document will be presented to the government in August 2014. It remains unclear within what timeframe the roadmap can and will be implemented.

A challenge in regulation of, and control on, mercury use in small-scale gold mining is that knowledge, responsibilities and authority with regard to the mercury issue are fragmented within diverse government offices. The Environment directorate of the Ministry of Labour, Technology and Environment (ATM) is responsible for making, executing and controlling environmental policy, including issues related to mercury. There are plans to move this directorate from the Ministry of ATM to the Cabinet of the President. It is not clear when this transfer will be completed. At present there is an Environmental Coordinator within the Cabinet of the President, but it is unclear how the tasks and responsibilities of this coordinator complement or differ from those of the Environment directorate of ATM.

Within the Ministry of ATM, the department for labour inspection has the authority to control labour conditions, including exposure to dangerous substances, and take measures where necessary. As a governmental foundation, NIMOS can advise policy makers but has no authority of execution. The GMD,

[4] This State Decree has been in preparation since 2010

which sits under the Ministry of Natural Resources, is by law responsible for control for the use of best practices in small-scale gold mining. At this moment, however, the GMD is hardly executing any control (B. Paansa, Chief exploration and geology GMD, pers. com. 26/05/2014). The Commission OGS is an executing agency and has a strong controlling function, but does not make policy. In short, there is no central management when it comes to the development, implementation and control on policy to regulate mercury in small-scale gold mining.

In order to reduce fragmentation of responsibilities and knowledge, and in an effort to more effectively prepare the country for signature of the Minamata Convention, the Cabinet of the President has approved the installation of a national mercury platform. The Commission OGS is taking the lead in its formation, and members include NIMOS, the Bureau for Public Health (BOG) and WWF Guianas).

3.2 Mercury in the gold mining process

Small-scale gold miners use mercury, which amalgamates with gold, to separate the gold particles from the soil, particularly when the gold is fine. The process is “cheap, simple, fast, independent, and reliable” (Telmer and Veiga 2009). Mercury plays a role in different stages of the gold extraction process (Figure 2). Gold miners are in contact with mercury and the toxin can be released into the environment at each stage, which makes the promotion of mercury-free alternatives imperative (Vieira 2006; for Suriname see Heemskerk and Olivieira 2003).

Figure 2. Mercury in different stages of the gold extraction process

(a) **Amalgamation**: Mercury is placed on the material that has been excavated, in the mining pit, in the sluice box, and/or in the bucket with concentrate. Gold amalgamates with mercury and forms larger clumps. More mercury can be added in the different stages of mining when the gold miners believe the amount is insufficient

(b) **Separation of the amalgam**: The mercury-gold amalgam is separated from the soil. Because the amalgam forms larger clumps rather than the sometimes dust-like gold particles, it is not difficult to separate it[5].

(c) **Removal of access mercury**: Miners collect the different mercury-gold clumps and place them together into a cloth. The cloth is squeezed so that the excess mercury drips through the cloth. The excess is typically caught for re-use[6].

(d) **Burning of the remaining amalgam to produce a gold sponge**. Different methods can be used to burn the amalgam. Miners can burn it in a gold pan on a wood fire or with a burner – whether or not covered with large leaves. Or else they can use a retort, an iron container that allows one to recycle the mercury. The working of a retort is explained in Section 4.5.

[5]Photo credits Paul Cordy; image obtained from website Biodiversity research institute. URL: http://www.briloon.org/research/research-programs/tropical-program/asgm

[6]Photo credits Paul Cordy; image obtained from website Biodiversity research institute. URL: http://www.briloon.org/research/research-programs/tropical-program/asgm

3.3 Effects of gold mining induced mercury contamination

A large number of studies have assessed the level of mercury contamination in fish, soils, and humans in the Guiana shield eco-region. Annex 1 summarizes some of the results for Suriname and neighbouring countries. With regard to the impact of mercury contamination on people, a more complete review on human mercury exposure and adverse health effects is provided by Passos and Mergler (2008).

River sediments are contaminated by mercury from small-scale gold mining activities in three main ways (Telmer and Veiga 2009):

- Liquid mercury that is used to amalgamate gold during the mining process partly escapes directly into water bodies as elemental mercury droplets or as coatings of mercury adsorbed onto sediment grains
- The mercury that forms the amalgam with gold is emitted to the atmosphere when the amalgam is heated – if a fume hood or retort is not used. The evaporated mercury comes down with rainfall.
- Naturally occurring mercury in soils and sediments that are eroded by sluicing and dredging becomes remobilised and bio-available in receiving waters

On the basis of measurements of mercury levels in 53 localities in Suriname, Ouboter et al. (2012) found that the average mercury level in bottom sediment surpassed the Canadian standard for sediment in most localities, except in the coastal plains. Mercury that naturally occurs in sediments may be released due to deforestation and the construction of dams. However, in the Amazon region these quantities are small as compared to the quantities of mercury released into the natural environment by small-scale gold miners. Indeed, for Suriname Ouboter et al. (2012) find that natural levels of mercury in geological formations are not a likely explanation for elevated levels of mercury in sediments of relatively pristine areas. Instead, his study, in line with other studies from Brazil and Guyana, suggests that mercury levels in the studied rivers have mainly an anthropogenic origin.

Inorganic mercury, the kind that is used by gold miners, transforms into a highly toxic state called methylmercury when it leaches into rivers where it is absorbed by ground-feeding organisms. Subsequently methylmercury -also named organic mercury- moves up and accumulates in the food chain through carnivorous fish. Of the predatory fish studied by Ouboter et al (2012), 41% had a mercury level above the European Union standard for human consumption of 0.5 µg/g. Extreme high levels were measured in Brokopondo hydropower lake (Figure 1), where in some cases the levels in piranhas were six to seven times the norm for human consumption (ibid).

People are primarily affected by mercury due to inhalation (mainly gold miners and gold buyers) or the consumption of fish (primarily inhabitants of river communities). People do not generally experience health effects as a result of skin contact as elemental (inorganic) mercury is only slowly absorbed through the skin, although it may cause skin and eye irritation (CDC 2013).

Studies in Indigenous and other riparian communities in the Guiana shield eco-region have found mean hair-Hg[7]levels that surpassed the recommended World Health Organization (WHO) safe level of10 µg/g Hg in hair (Annex 1). In Suriname Wayana Indigenous communities, Peplow and Augustine (2007) found mean hair Hg concentrations of 14 µg/g (Apetina) and 8 µg/g3 (Kawemhakan)[8]. In neighbouring Guyana, health researchers have found hair-Hg levels in Indigenous communities ranging from 2 to 22 µg/g (Colchester et al. 2002). In one study community 96% of the population displayed Hg-hair values higher than 10 µg/g (ibid.). To the east, in French Guiana Wayana Indigenous communities along the border with Suriname, research has found a mean Hg level of 11,4 µg/g in hair (InVS 1997). A review of human mercury exposure in the Amazon region reported mercury levels as high as 38.6 ± 14.4µg/g and 65 ± 58µg/g among fish consumers in riparian communities (Passos and Mergler 2008). In Amazon communities as well as worldwide, fish consumption constitutes the most important source of Hg exposure.

Mercury vapour that is inhaled, for example while burning the amalgam (Fig. 1.d), enters the body in its inorganic form, where it is absorbed into the blood. When the concentrations are large and/or exposure is long, exposure to inorganic mercury can cause acute mercury poisoning, which causes several health effects including chemical bronchiolitis and pneumonitis (Asano et al. 2000). Once in the circulatory system, inhaled gaseous mercury can pass through the blood-brain barrier and accumulate in the brain. It may damage the nervous, gastrointestinal and immune systems, lungs and kidneys. In addition, the inorganic salts of mercury are corrosive to the skin and eyes (WHO 2013). And, in the end, it may be fatal. Yet as compared to organic mercury, inorganic mercury is not as easily absorbed by the human body.

A more severe health risk results from organic mercury poisoning or methylmercury poisoning due to the consumption of fish and shell fish. Methylmercury is easily absorbed in the digestive tract and more easily gains entry into cells. As with inorganic mercury, once in the bloodstream, methylmercury will accumulate in the brain and cause damage to the central nervous system (Griesbauer 2007).

With methylmercury exposure, paresthesia is the first and mildest symptom observed, where a tingling or numbness is felt in the hands, arms, legs, or feet, but can also occur in other parts of the body (Griesbauer 2007). In the case of methylmercury poisoning, this numbness is the first sign of damage to the nervous system. Particularly in children exposure to mercury may cause acrodynia or pink disease; a form of skin discoloration resulting in pink cheeks, fingertips and toes. Other symptoms that may follow a higher dose of methylmercury poisoning are ataxia (stumbling or clumsy gait), generalized weakness, peripheral neuropathy (presenting as paresthesia or itching, burning or pain), swelling, and desquamation (shedding or peeling of skin). Furthermore, symptoms related to mercury poisoning are generally also related to some form of alterations in the workings of the nervous system, such as mood swings, headache, tremors, weakness, insomnia, emotional/behavioural changes, irritability, decreased cognitive functions and so forth (Drs. J. Ligeon, MD, pers. com. 16 July 2014).

[7] Hair-Hg is considered to be a good indicator of Hg exposure through fish consumption

[8] Because this researcher did not follow the prescribed ethical regulations with regard to health research in Suriname and did not obtain approval of the Suriname Medical Ethical Committee, the presented research results have been contested by the Suriname government.

Higher doses of methylmercury poisoning may lead to motor speech disorder, loss of vision and hearing, tremor, and finally, coma and death (ibid.). A congenital form of Minamata disease can also affect foetuses in the womb. To date, these more severe symptoms have only been observed in people who consumed fish that were contaminated directly by methylmercury from anthropogenic sources, not from methylmercury that accumulated through the natural methylation process. For Suriname there are, as far as we could confirm, no registered cases of persons with severe symptoms of Minamata disease.

3.4 Treatment of mercury poisoning in people

Consulted medical specialists revealed that mercury poisoning is overall a very difficult to treat condition, and can often only partially be treated (Drs. J. Ligeon, pers. com.15 July 2014). The reason is that, after exposure, mercury does not stay in the blood stream but it exits the blood stream and deposits elsewhere where it rapidly gets bound to various types of tissue. At this point mercury has "permanently" deposited and infiltrated the tissues, where it can interfere or do further damage. The tissues most often affected by mercury, after it leaves the blood stream, are: the nervous tissue (by far the most), the kidneys, and the lungs.

It is generally believed that once the mercury binds to these tissues, it is very difficult (or impossible) to reverse the actual tissue poisoning and in essence there would be permanent damage. There have been trials with a few medicines but none have shown much benefit. Thus, as of today, medical specialists do not know of any effective treatment for chronic mercury poisoning (ibid.).

The only offered treatment currently known for mercury poisoning is the use of Chelating Agents[9], which are commonly used for Iron or Lead poisoning. However, these types of drugs would only work on mercury which has not yet been deposited at the tissue level, and hence would only be effective in acute mercury poisoning. However, by far, most cases of mercury poisoning are found in the chronic state (in people who for example have long ingested mercury), where mercury has already tissue-deposited for a long time. As a result, even chelating agents have really not been very effective in treating mercury poisoning in general. Also, Chelating Agents have virtually no effect in treating mercury poisoning from a vaporized form (inhaled), because the toxin is immediately bound to tissue receptors in the lung and nervous system (ibid).

As we will show in Chapter 4, many people believe that a blood transfusion or replacement of the blood will get the mercury out of the body. Medical specialists call this impossible (Drs. E. Dams, pers. com. 15 July 2014) and not supported by concrete scientific evidence (Drs. Ligeon, pers. com.15 July 2014). After all, even a replacement of the entire blood volume (Plasmapheresis) would only hypothetically work for unbound mercury and do nothing at the tissue level, where bound-mercury causes most or all of the problems.

[9] a general term for a drug that is used to bind to an unwanted substance in the body

3.5 Knowledge and awareness about mercury among small-scale gold miners

A 2004 study in Suriname Maroon communities found that most interviewed Maroon gold miners[10] (N=173) were reasonably aware of the general health risks of exposure to mercury; 83.7 percent could name behaviours that pose one at a risk for mercury poisoning (Heemskerk and Olivieira 2004). The largest share of miners (80.2%) knew that the mercury vapour that develops as a result of burning the mercury–gold amalgam is hazardous. Smaller numbers of Maroon gold miners knew that the consumption of polluted fish and skin contact with mercury also posed a health risk (resp. 48% and 24.5%).

On the other hand, interviewees were poorly informed about the types of fish and fish parts that contain the highest levels of mercury; about what happens to mercury once it has entered the human body; and about the clinical symptoms of mercury contamination. At the time, very few gold miners were aware of the existence of retorts to recycle mercury, or of methods to work without any mercury. Results of the present study will show that after one decade very little has changed in terms of small-scale gold miners' general knowledge about mercury and its effects on human health. Because earlier projects to raise awareness and implement cleaner technologies (see section 3.6) have not been evaluated, we can only speculate about reasons behind their limited impact. It is possible that the mobility of mining populations has played a role (i.e. we are now talking to new populations), but the lack of long-term success may also be related to the fact that some interventions did not appeal to the gold miners (e.g. the type of retort was user-unfriendly), and that the projects were top-down and lacked follow-up.

The recently adopted Minamata Convention calls for nations to do awareness-raising for small-scale gold miners. We hope that this study will be a first step towards the development of such an awareness campaign.

3.6 Lessons learned from efforts to motive small-scale gold miners to reduce or eliminate the use of mercury

The Global Mercury Project[11](GMP) has executed an intensive program aimed at increasing gold miners' awareness about the health risks of mercury and demonstrating cleaner technologies in many different countries. In Brazil, the campaign included training of a large number of *garimpeiros* (gold miners); introduction of best practices in *garimpos* (incl. mercury confinement/pool for amalgamation, reactivation and recycling of mercury), development of a demonstration plant; and the donation of retorts. Workshops were held with authorities and an extensive media campaign was launched to promote the program. The GMP estimated that by improving mercury reactivation and reuse to 91.7 percent, the program activities have resulted in a ~10 percent reduction in the amount of mercury released in the target area.

[10]Migrant miners were not part of this study

[11] The Global Mercury Project (GMP) has been sponsored since August 2002 by the Global Environmental Facility (GEF), with the United Nations Development Program (UNDP) as the Implementing Agency and the United Nations Industrial Development Organization (UNIDO) as the Executing Agency.

In Suriname, projects aimed at reducing mercury use among small-scale gold miners have been executed on a much smaller scale. In 1998, the Geology and Mining Department (GMD) in collaboration with PAHO introduced retorts in all known mining areas in Suriname. This model had a capacity of 2 kg and a burning time of 45 min. up (burning) and 45 min. down (cooling down), hence a total of 1½ hours. The extensive time required for burning the amalgam concerned miners because it made them vulnerable to robbery and assault. As a result, few if any gold miners adopted the retort.

In 2005 another retort promotion project was executed by the GMD in collaboration with WWF. The community of Nw. Koffiekamp was among the pilot locations. A different model retort was demonstrated and left behind for the gold miners. Safety (robbery) was not an issue at this location because the small-scale gold miners worked on the terrain of a multinational Mining Company. Hence the area was fenced and guarded. The consultant was unable to locate records on the project results and the project was never evaluated, so we do not know how gold miners reacted to the retorts at the time. However, when the researchers visited the area for the KAP study interviews in 2014, none of the interviewed miners remembered this workshop and none were using a retort.

In 2011, the communication company Forward Motion, with endorsement of the Commission OGS and financial support of WWF-Guianas, executed an "Environmental Education & Awareness Campaign for the Gold Mining Sector of Suriname." According to the project document, this project was to be executed in Brownsweg, Lawa, Tapanahony, Saramacca, Nassau, and Brokopondo. Among the expected outputs was that "75% of the miners, community's residents and other stakeholders of the targeted areas have acquired the knowledge through comprehensive environmental awareness campaigns to promote better practices in the small scale gold mining sector." It is unclear whether field activities have actually taken place and as far as could be ascertained, this project has not generated tangible results.

In 2012-2013, the Commission OGS demonstrated the use of retorts in the Merian area and Matawai. Thirty retorts were handed over to the miners (G. Dompig, head OGS management team, pers.com. 26/05/2014). In its initial year, the Commission OGS also ordered several equipment sets that would allow for mercury free mining. A recent evaluation of these systems has pointed out that their capacity (~2 tonnes/hr) is too small for present-day gold miners in Suriname (C. Healy, anthropologist and OGS consultant, pers. com.15/08/2014). More recently, the Commission OGS has acquired a complete line-up of machinery for mercury-free gravity concentration for small-scale gold miners[12]. This plant has been mounted on a platform, and the idea is to bring it to the interior for demonstrations. While the mercury free technology is appealing, it may not be easily transferable to Suriname's small-scale gold miners. In the first place, at USD 300,000 the machinery is expensive. Secondly, operation of the plant requires the involvement of persons with a certain degree of technical education, which few gold miners possess (C. Healy, anthropologist and OGS consultant, pers. com.15/08/2014).

In addition, there have been private initiatives to promote the reduction of mercury consumption and related spillage. For example, at the Nana Resources concession at Lawa, gold miners who operate their

[12] The mineral processing plant was obtained at the iCON gold recovery corporation,
URL: http://www.iconcentrator.com/

own machines on this concession (e.g. sub-letters) have been obliged to use a retort and tailing containment. Compliance with these requirements is controlled during regular inspections, and non-compliance may result in closure of the pit. A 2009 evaluation of the Nana Resources Environmental Management System (NEMS) suggests that the inspections incentivized some equipment owners to work cleaner (De Theije 2009). For example, two equipment owners who were not using a retort before reported that they started using one after the inspection, and they were happy with it. On the other hand, there seemed to be little progress in motivating mines to work in a closed circuit to reduce the spillage of mine tailings. Inspection reports showed an increase in the number of pits that washed the concentrate in the open water instead of in a closed bucket (ibid.)

None of the mentioned projects in Suriname has been evaluated, and hence we do not know much about the impact they have had.

Lessons and Challenges

In a review article of *World Emissions of Mercury from Artisanal and Small Scale Gold Mining*, Telmer and Veiga (2009) present two main lessons for programs aimed at reducing mercury consumption among small-scale gold miners. In the first place, it must be acknowledged that the use of mercury for gold extraction is cheap, easy and efficient, and "so in many settings, it is hard to beat" (p. 134). For that reason, they continue:

> … as a first line of intervention, it may be more appropriate to try to reduce mercury consumption through conservation practices like retorting, fume hoods, and mercury re-activation or cleaning (making dirty mercury usable again and thereby preventing it from being discarded into the environment), rather than immediately aiming for the total elimination of mercury use. The introduction of conservation practises can easily reduce mercury consumption by 50 to 90% and it is an easily accepted change in practice – one that can even have the powerful incentive of being profitable…
> (Telmer and Veiga 2009: 134)

Also Suriname policy makers acknowledged that mercury-free technology is expensive, and that phasing out mercury may be more realistic than a sudden prohibition. Phasing out mercury is also part of the NIMOS roadmap. A plan and time-lime for the complete elimination of mercury from small-scale gold mining is yet to be developed (NIMOS 2014).

In the second place, the listed researchers refer to the "the differing cultures of various intervention efforts" as a factor that is critical to the success or failure of intervention measures. They argue that it is critical to understand the socio-economic and environmental realities of gold mining communities. Well-meant interventions have failed, they say, because these interventions did not sufficiently consider existing customs and traditions, and the financial burden that interventions might cause.

With regard to the miner's attitudes, studies elsewhere suggest that gold miners may be open to change, but only if it is a rational change and brings them something better (Telmer and Veiga 2009). Policy makers acknowledged that not only gold miners should change their attitudes, but also the government itself. For years the government has executed a policy of tolerance (*gedoogbeleid*) and it

will be difficult to prohibit behaviours that have been allowed for years (F. Hausil, Legal expert at NIMOS, pers. com. 30/06/2014). At the same time, government offices must change their laissez-faire attitude and execute more control. We expect that the present study will provide insights in what may be rational and acceptable changes for the different stakeholders.

Riverside non-mining communities, which are most vulnerable to methylmercury exposure, typically have a limited role in mercury awareness activities. Mercury levels have been measured in different populations (e.g. Apetina, Kwakoegron, Brownsweg, Lawa), but these the populations have not been involved in communication with gold miners about mercury use. Complicating matters is that gold miners and river communities are not two different groups. Instead many community members (or their urban relatives) are gold miners or in other ways earn directly or indirectly from gold mining near their communities. That is, the communities that suffer the (partly invisible) impacts of gold mining economically depend on gold mining. Moreover, the KAP study will show that gold miners generally are unaware about the distant impacts of their activities.

Suriname policy makers[13] emphasized that it is important to listen to complaints and find answers. As one of the main challenges in the case of Suriname, they identified the fact that Suriname's small-scale gold miners typically do not have mining titles and hence they can be removed any time. Mining titles provide a certain level of stability and security, which may facilitate the introduction and adoption of alternative methods and techniques. The following examples were named:

- A gold miner with a title is linked to a certain site and the government can influence the way that the gold miner builds his camp and works. But a person without mining title may move from location to location, which complicates monitoring and follow-up.
- Without mining title gold miners are unlikely to invest in cleaner technology because they risk losing this investment.
- If people work in delineated working areas you can make them agree to written regulations, such as phasing out of mercury. The government or organizations can also offer incentives to miners who, for example, work without mercury and actually take mercury out of the ground from earlier gold mining activities.

A lack of awareness was also named as one of the challenges with regard to a transition to a small-scale gold mining sector that more consciously works with mercury. One particular aspect is that mercury does not affect individuals from one day to the other. Because ill people leave the sector silently one does not see the effects of mercury poisoning, which in turn makes it difficult to convince gold miners of the adverse health effects of contact with mercury. Also in the present study we find that awareness is suboptimal.

[13]B. Paansa, Chief exploration and geology GMD (pers. com. 26/05/2014); F. Hausil, legal department NIMOS (pers.com 30/6/2014); G. Dompig, head OGS management team, pers.com. 26/05/2014

4. RESULTS

4.1 Population characteristics

Of the 178 small-scale gold miners in the survey sample, 115 (64.6%) were Suriname nationals, 58 (32.6%) were Brazilians and 5 (2.8%) were Guyanese. One third of survey respondents (33.7%, N_{total}=177) said that they called the area where they were working their home or traditional living area. Among them were 17 Brazilians. They reasoned that they were living, sleeping, eating and working in the mining area for such an extensive period of time that they felt this was their home.

On average, surveyed gold miners were 36.7 years of age at the time of the interview, with the youngest interviewee being 17 years of age and the oldest 62 (N=178). Surveyed migrant miners were, on average, five years older than Suriname miners (t-test, $p<0.005$). All but one interviewee, a Brazilian *dona de maquina*, were male. Almost one quarter of interviewees consisted of equipment owners (23.6%), seven (3.9%) individuals -all Suriname miners- were supervisors, and the remaining 129 persons were labourers (72.6%). Characteristics of the survey sample are summarized in Table 2.

Table 2. Sample characteristics (N=178), comparing Suriname miners and migrants

Characteristic	Suriname nationals (N= 115)	Migrant miners (N=63)
Age*	Mean = 34.9; Range 17 - 62	Mean = 39.9; Range 18 - 58
Profession	20.9% equipment owners 74.0% labourers/workers 6.1% supervisors	28.6% equipment owners 69.9% labourers/workers (1 missing)
Education*	Mean number of educational years completed: 7.0	Mean number of educational years completed: 5.4
Mining experience	<1 year: 7.0% 1-3 years: 16.5% 4-7 years: 23.5% > 7 years: 53.0%	<1 year: 7.9% 1-3 years: 15.9% 4-7 years: 25.4% > 7 years: 50.8%

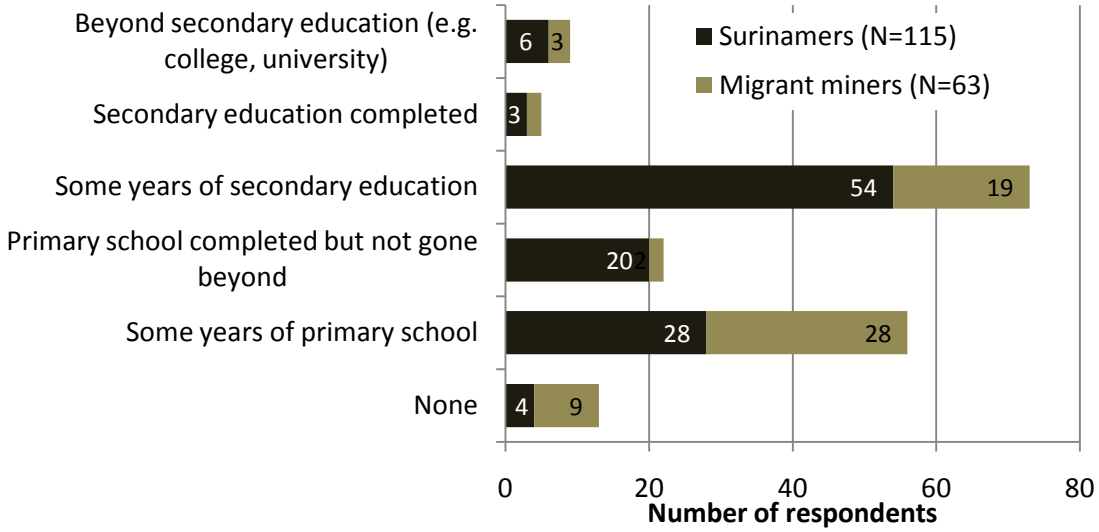
*Significant difference between the groups

Surveyed gold miners had a considerable amount of experience in small-scale gold mining, and hence most of them had been dealing with mercury for quite some time. More than half of interviewed gold miners had been working in mining for more than seven years (52.2%; N_{total}=178). Another quarter of the sample population had between four and seven years of mining experience (24.2) and 16.3 percent of surveyed gold miners had been working between one and three years in their current profession. A smaller proportion of the sample was relatively new to this sector (7.3%). There was not much difference between Suriname nationals and migrants in terms of the average length of their mining history. It was noticeable that several Brazilians had been working as *garimpeiros* for some decades (in Suriname and elsewhere), since the 1970s. It was uncommon for Suriname gold miners to have so many years of mining experience.

Educational achievement was generally low. On average, survey respondents had enjoyed just over six years of formal education (Mean=6.4). The range was wide though, with thirteen persons (7.3%;

N_{total}=178) reporting that they had not been to school at all, and nine individuals (5.1%; N_{total}=178) with more than 12 completed school years, meaning they had attended tertiary education. On average, Suriname gold miners had completed more years of formal education than foreign gold miners. Notable was that among the five Guyanese gold miners, two reported having attended tertiary education.

Figure 3. Educational achievement of surveyed Suriname and migrant gold miners

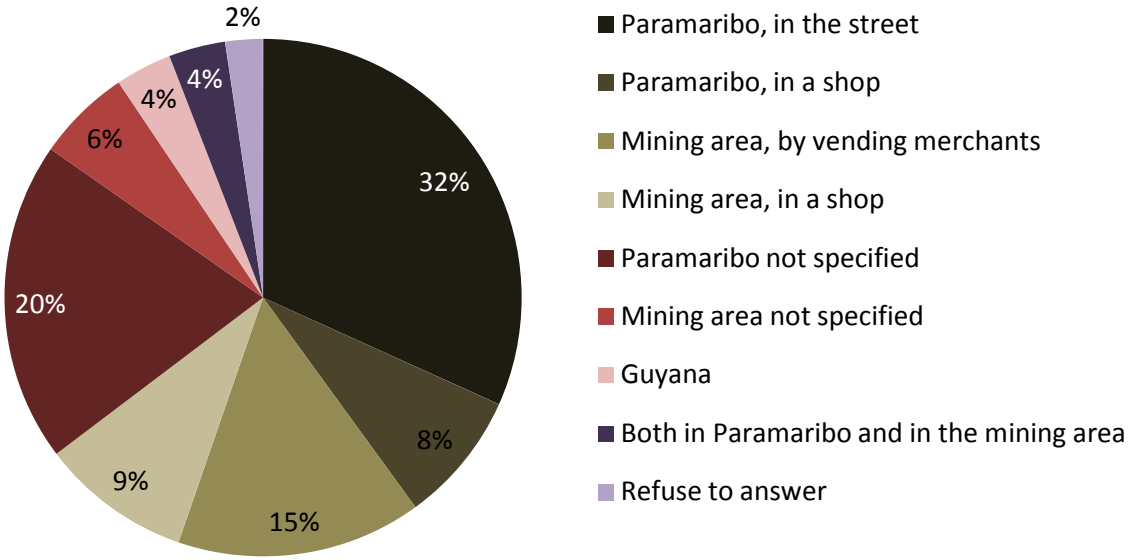


4.2 Acquisition of mercury

The mercury use cycle in the small-scale gold mining sector starts with the acquisition of mercury. When asked about their acquisition point the last time they bought mercury, half of the gold miners said they had never bought mercury (51.7%; N_{total}=178). They usually were workers in the mine, and commented that the equipment owner was responsible for providing the mercury. We suspect some under-reporting because many gold miners were convinced that buying mercury is illegal and they may have been hesitant to admit that they had indeed bought it. One person said, for example, "I cannot answer because it is illegal." A colleague commented: "I buy it in Paramaribo, often in front of the VCB [a Suriname bank in Paramaribo centre] but not a fixed spot because it is forbidden."

More than half of those who provided a location where they last bought mercury had bought this substance in Paramaribo; in the streets (31.8%), in a shop (8.2%), or in an unspecified location (23.4%; N_{total}=85) (Figure 4). Other survey respondents named more specific location such as in front of the central market, CHM, or Combé. Nine persons specified that they bought it in Paramaribo north, in the area that is also referred to as "Little Belem" because of the large number of Brazilians that frequent this area. Informal sales persons (*hosselaars*) and cab drivers seem to be the main vendors of mercury in Paramaribo. The responses suggest that the vendors of mercury were usually Suriname nationals.

Figure 4. Places where small-scale gold miners last bought mercury (N=85)



A smaller share of small-scale gold miners indicated that the last time they had bought mercury they had bought it in the mining area; from a shop (9.4%), a travelling merchant (15.3%) or an unspecified location (9.4%; N_{total}=85). Three persons had bought mercury in Guyana the last time they had obtained it.

The price for one kilo of mercury was reportedly 200 USD or 5 g of gold when bought in the city, and 10 g of gold when bought in the mining area. These figures, which were the same in the different visited areas, suggest that the price of mercury is substantially higher in Suriname than that it is on the world market (< 100 USD/Kg). Furthermore, looking at the world market price for mercury we see that this price has risen considerably in the past couple of years. Whereas mercury cost under 18 USD/kg in 2007-2009, this price increased to 31 USD/Kg in 2010, to 57 USD/Kg in 2011, and 91 USD in 2014.

Despite this five-fold price increase there are no indications that gold miners make an effort to reduce their mercury expenditures. Perhaps, with a price of 5 g of gold for 1 kg of mercury, there is still too little incentive to economize on the use of mercury. [14]

4.3 Amalgamation

Amalgamation is efficient for liberated or partially liberated gold, and for particles coarser than 200 mesh (0.074 mm) (Veiga et al. 2006). Coarse nuggets do not need to be amalgamated; gold miners pick them manually, either with a metal detector or from the concentrate in a baté or sluice box.

When asked about mercury use in the small-scale gold mining process, virtually all gold miners (97.8%) admitted they used mercury in the mining process, while four gold miners (2.2%) reported that they did

[14] On August 4, 2014, the international price of gold was 41.43 USD/gr.

not use mercury. Of the four gold miners who reported that they did not use mercury, one worked with a metal detector; he was a so-called *pewpewzeiro*[15].

Another gold miner in this group said he had just arrived and was at the moment just washing gold with a baté. In fact, working with a baté in a place that had been mined before, the gold he found typically already was amalgamated with mercury (Figure 5). One gold miner reported that he was working with a crusher and a centrifuge, and one person said he mined gold with a sieve and did not need mercury.

Figure 5. Baté with amalgamated gold

The use of mercury is beneficial to the mining process for different reasons. The largest group of miners said the main function of mercury is to capture the gold (74.4%; N_{total}=164). "There is no other way to wash the gold," explained one of the miners, "Without mercury you will lose everything".

One third of gold miners specified that mercury helps capture the very fine gold (38.4%;N_{total}=164). With regard to the latter, several gold miners commented that they used very little mercury when they noted that the gold was coarse. Another gold miner stated that mercury binds the dust gold to the coarser gold particles, so that they stick together.

Several interviewees provided additional explanations. Some respondents, for example, said that working with mercury you find more gold: "…if, for example, you find 10 grams of gold without mercury, you will find 20 grams with mercury". It was also said that using mercury, one gets the gold faster and/or easier. One person commented that since the gold now is found in smaller quantities (as compared to before), you need to use mercury to capture that little bit. Some people have a slightly distorted perception of the amalgamation process. For example, one gold miner said that one needs mercury "to draw the gold out. Gold will turn into dust if it is not being properly processed."

It is difficult to determine precisely at what stages in the gold mining process gold miners add mercury, because the application of mercury varies depending on various factors. As a general rule of thumb we found that the application of gold in the different mining stages was dictated by:

- **Habit, knowledge and experience** of the equipment owner. Some gold miners would always apply mercury in different stages of the mining process, whereas others indicated that it was sufficient to, for example, only apply mercury when washing the sluice box, that is, during the final concentration (Por: *dispescar*). One equipment owner even conveyed that using too much mercury was counter-productive and led one to lose more gold.
- **Observation of, or perceptions about, the quantity of gold**. Miners look at the colour of the gold in the concentrate, and if it is still "too yellow" they will add a bit more mercury. Also, as gold deposits are becoming depleted miners said they needed to use more mercury.

[15]Named after the local name for metal detector: pew pew.

- **Previous use of mercury at the location**. When you work somewhere where someone else worked before, sometimes there is still sufficient mercury in the unprocessed material and you do not need much more.
- **Observation of the coarseness of gold**. When the gold is fine or dust-like, gold miners tend to apply relatively more mercury. Some individuals explained, for example, that they would place mercury on the material that is excavated only when the gold is very fine, but when the gold is coarser they would only use mercury when washing the concentrate.

From the above it may be inferred that mining teams do not necessarily use the same amount of mercury in the same stages of the mining process for every pit they excavate.

The data suggest that most gold miners use mercury in more than one stage of the mining process. These different stages are explained in Figure 6, labelled I through IV. Stages I and II are part of whole ore amalgamation, whereby mercury is mixed with the whole ore; in the pit, in pump boxes, in sluices during gravity concentration, in the grinding circuit, or on copper plates.

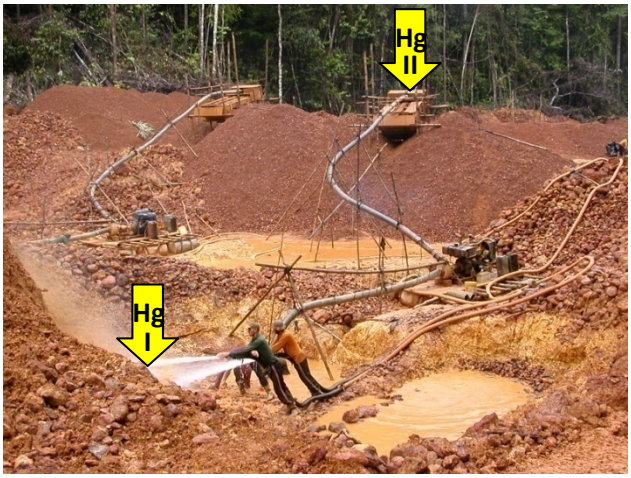
Sixty percent of interviewed gold miners reported that in the operation where they worked, mercury was always applied to the unprocessed ore; on the excavated material, in the mining pit, or in the canal through which the water is diverted into the sluice box (60.3%; N_{total}=174). Another 10.9 percent of gold miners conveyed that they sometimes applied mercury in stage I (Figure 7).

Surinamese gold miners were relatively more likely than migrant miners to perform whole ore amalgamation (resp. 76.1%; N_{total}=113 versus 62.3%; N_{total}=61). The difference is even larger when only considering the equipment owners, who typically make the decisions about when, where and how much mercury to apply. Of the Surinamese equipment owners, 70.3 percent reported using mercury on the unprocessed material, versus 33.3 percent of migrant equipment owners (resp. N_{total}=30 and N_{total}=12). The data also suggest that more experienced gold mining equipment owners were relatively more likely to throw mercury on the unprocessed material. Of gold miners with more than seven years experience in gold mining, 63.3 percent reported that they always or sometimes used mercury in this stage (N_{total}=30), versus one third of gold miners with seven or fewer years of mining experience (33.3%; N_{total}=12).

Figure 6. Application of mercury in different stages of the small-scale gold mining process

I. Application of mercury to the unprocessed soil (whole ore amalgamation). Gold miners sprinkle mercury on the material that has been excavated in the mining pit or canal through which the gold bearing slurry is sucked up and led to the sluice box (stage I). They typically use a piece of cloth in which the mercury is placed, but also drinking bottle caps or their bare hands to do so.

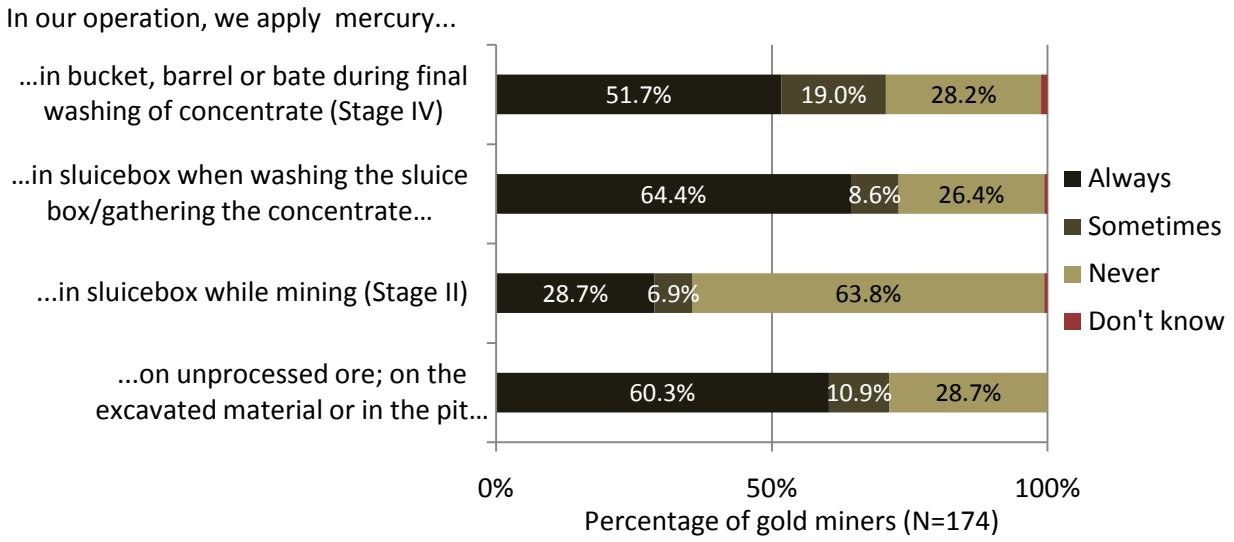
II. Mercury is applied in the sluice box during the mining process.



III. Mercury is applied when washing the sluice box (Bra: *despescar*; Sur: *nak' a moketi*). In this process, the iron wire is removed from the boxes and the rubbery mats –which hold the gold particles- are washed.

IV. The concentrate from the sluice box is collected in a bucket or barrel. In this stage the concentrate usually already contains mercury that was applied in stages I, II and/or III. The concentrate is washed with a gold pan (baté). Gold miners may add (additional) mercury to the concentrate in this stage.

Figure 7. Percentage of interviewed gold miners who always, sometimes or never apply mercury in different stages of the mining process



There was little uniformity in comments related to how much mercury gold miners would use on the unprocessed ore. Several gold miners said they habitually added about 50 g of mercury to the excavated material, but narratives of gold miners illustrate that the amount of mercury applied in the different stages is seldom straightforward, and differs between pits and teams:

> "For example, when you work with an excavator, you sprinkle the mercury on this material. You turn the baté, and depending on the result you determine how much you need to use. Say, a pile of sand of 10 to 15 'kub' (m^3) and you find one deci in the baté, so you will need to use about 200 g [of mercury] for that pile. […] If you work at a place that has been worked before, there is sometimes already enough mercury in it and you do not need much more. But if the gold is so fine that it almost floats on water, you add a bit more." (Suriname mine labourer and former equipment owner at Roma).

> "… You look at the pile [dug up by the excavator] and you place one bottle cap. When you wash the *moketi* (carpets in the sluice box) and you see that the gold is still yellow, you add a little more. Once the gold is grey you do not add any more [mercury]." (Suriname labourer at Pikin Saramacca)

> "We apply mercury on the pile of the excavator, for example 10 g. You wash a bit of the material from the sluice box in a *cuie* (small gold pan). If you see fine gold without mercury attached to it, you put a little bit more. We throw mercury on every new pile when the gold is still "dry". However, when the gold is coarse we hardly use any mercury. In fact, one kg of mercury can catch three kg of gold. We can work two months with one kg of mercury." (Suriname equipment owner at Km 16)

> "On the excavated material we apply a bit of mercury every day, for example 50 g in the morning and a bit more in the afternoon. So, during one entire week or two weeks we

> add 60 to 80g [of mercury] a day. You look in the canal [from where the slurry is sucked up] and in the sluice box, and from experience you know when it is enough. The finer the gold, the more mercury you need. A *garimpeiro* just wants to find gold." (Brazilian equipment owner at Tumatu).

Whole ore amalgamation uses mercury very inefficiently, taking an estimated 3 to 50 units of mercury to produce 1 unit of gold (Av. ~ 5) (Telmer and Veiga 2009). During whole ore amalgamation most of the mercury loss initially occurs into the solid tailings, which are often discharged directly into receiving waters and soils. This mercury persists in the environment for centuries (ibid.).

It is relatively less common to place mercury in the sluice box during the mining process; almost two-thirds of small-scale gold miners responded that they "never" used mercury in stage II (Figure 7). Using mercury in this stage is not very efficient because a considerable amount will flow away with the tailings. Veiga et al. (2006) report about this process:

> Mercury in sluices is a very inefficient method still used by some artisanal gold miners--sluice boxes built with riffles are loaded with mercury. When the pulp with gold flows through the sluice, the riffles trap the gold and the amalgam is formed simultaneously. This is a very inefficient and polluting process. The contact time is very short and large portions of mercury are lost. Some miners believe that gold recovery can be improved by using Hg in the riffles. This is NOT TRUE. Tailings from sluices boxes operating with mercury are very rich in gold as well as mercury. Sluice boxes are excellent for gold concentration but should not be used to amalgamate gold (Veiga et al., 2006).

Nevertheless, about a quarter of surveyed small-scale gold miners reported that they "always" placed mercury in the sluice box when operating the hydraulic hoses. One person reported that he would place mercury in the crusher (gold mill). An expert from the GMD conveyed that this does not make any sense because the mercury will simply sink to the bottom (B. Paansa, Chief exploration and geology, Geology and Mining Department. pers.com. 26-05-2014). Veiga et al. (2006) confirm:

> Amalgamation in grinding mills is an insane process that mixes all of the ore to be ground with mercury in ball or rod mills. This leads to considerable loss of gold, and to extreme loss of mercury (p. 58).

Some gold miners who worked with a crusher also placed mercury in the sluice box part of the crusher set-up, or rubbed it on the copper plates[16] directly behind the sluice box. About mercury that is rubbed on the copper plates, Veiga et al. (2006) say the following:

> The efficiency of the process depends on the operator's ability, but usually is low due to the short time of ore-mercury contact because the plates are usually only 0.8 m to 1.5 meters in length. Abrasion of the pulp of ore with the copper-mercury surface releases mercury droplets which are carried away with the tailings. Amalgam is removed by

[16] Copper plates are a form of sluice where mercury is used as the trapping mechanism instead of riffles or carpets

> scraping, periodically interrupting the process. When scraping the surface of the copper-mercury plates, miners are exposed to high levels of mercury vapor and become contaminated (p. 58).

Gold miners typically apply mercury in the concentration phase (Stage III), and mostly in the sluice box when washing the carpets (*moketi*) that capture the gold. Two-thirds of gold miners, among those using mercury, reported always applying mercury in this stage (64.4%), while 8.6% of interviewees do so "sometimes" (Figure 7). In addition, just over half of surveyed gold miners said they "always" applied (additional) mercury in the final concentration phase, when the concentrate from the sluice box has been captured in a bucket or barrel and is washed with a baté. While some mining teams habitually add mercury at this stage IV, miners from other mining teams said they did so only sometimes (19.0%), when it was "necessary" (e.g. given the colour of the gold).

Telmer and Veiga (2009) have calculated that where only a gravity concentrate is amalgamated, losses are normally about one to two units of mercury for each unit of gold produced. These losses can be significantly lower if a mercury capturing system is used when the amalgam is burnt, such as a retort.

4.4 Burning the amalgam

Once the gold has amalgamated with mercury it is easily recovered from the ore, using a baté. After squeezing out the excess mercury in a cloth, the mercury has to be burned off so that the gold remains. This can be done on a wood fire, with a gas burner, or in a retort (Figure 8).

Gold miners did not show a strong preference for burning the amalgam either on a wood fire or with a burner (Figure 9). Similar numbers of surveyed gold miners reported that they "always or most often" use a wood fire (47.6%; N_{total}=168) or a burner (51.8%; N_{total}=168). Furthermore, 19.6 percent of surveyed gold miners indicated that they "sometimes" use a wood fire, and 17.3 percent revealed that they "sometimes" use a burner. There was not much difference between Suriname gold miners and migrants with regard to their choice for either a burner or a wood fire for burning the amalgam.

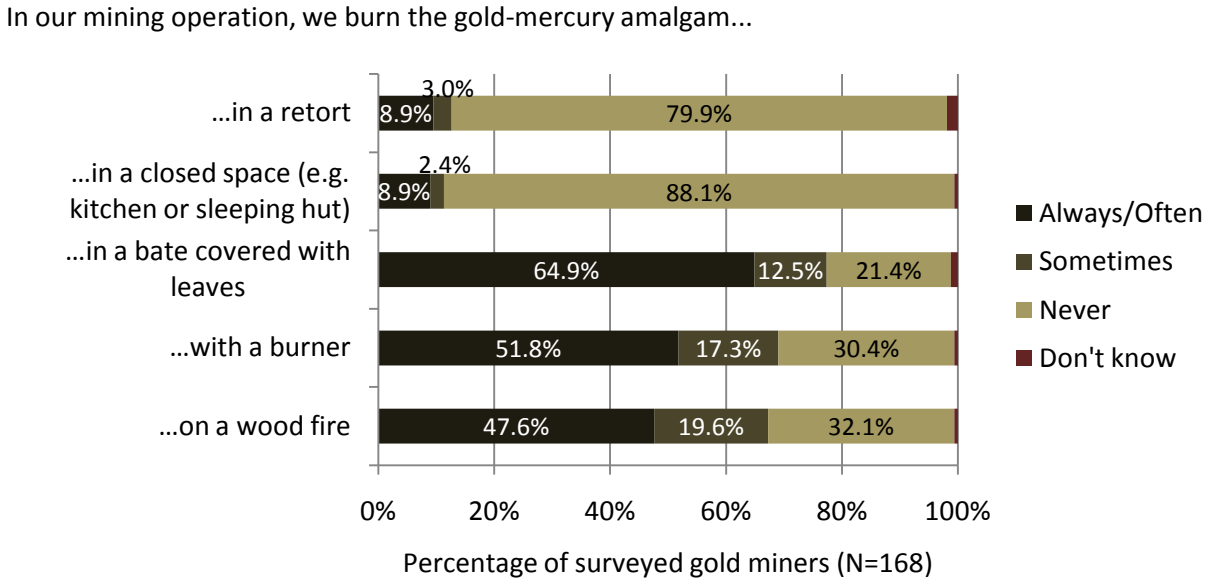
Almost two-thirds of surveyed gold miners (64.9%; N=168) conveyed that when they burned the amalgam, they covered the baté with large leaves (e.g. of the *Cecropia sp*.) to prevent the vapour from escaping into the air. Covering the gold pan with leaves was relatively more common when burning on a wood fire. Instead of leaves, a selected few gold miners occasionally used other items such as a piece of corrugated sheet or carton board. When burning the amalgam, the evaporated mercury sticks to the leaves, and can be recovered by washing the leaves in water. Several gold miners, however, said they did not recover the mercury. They simply throw the leaves, with the mercury attached to it, away in the forest. Suriname gold miners (86.6%; N_{total}=112) were more likely than migrant miners (53.3%; N_{total}=60) to always/most often or sometimes cover the baté with leaves when burning the amalgam.

Figure 8. Burning the mercury gold amalgam on a wood fire, with a gas-burner, or with a retort

A 50-year old Brazilian equipment owner who had been working in the small-scale gold mining sector since the 1980's admitted that he does not cover the baté with leaves because:

> "You come home in the evening and you want to burn rapidly. There also may be robbers, so you do not think about leaves. Look, a *garimpeiro* is not afraid of mercury because there isn't anything you can do to protect yourself anyways. My granddad already told me: "*garimpo* is illusion".

Figure 9. Percentage of small-scale gold miners who reported that they always, sometimes or never burn the gold-mercury amalgam in a certain way



Most small-scale gold miners are conscious about the health risk of burning the gold-mercury amalgam in a closed space; 88.1 percent of gold miners expressed that they "never" burned the gold in the

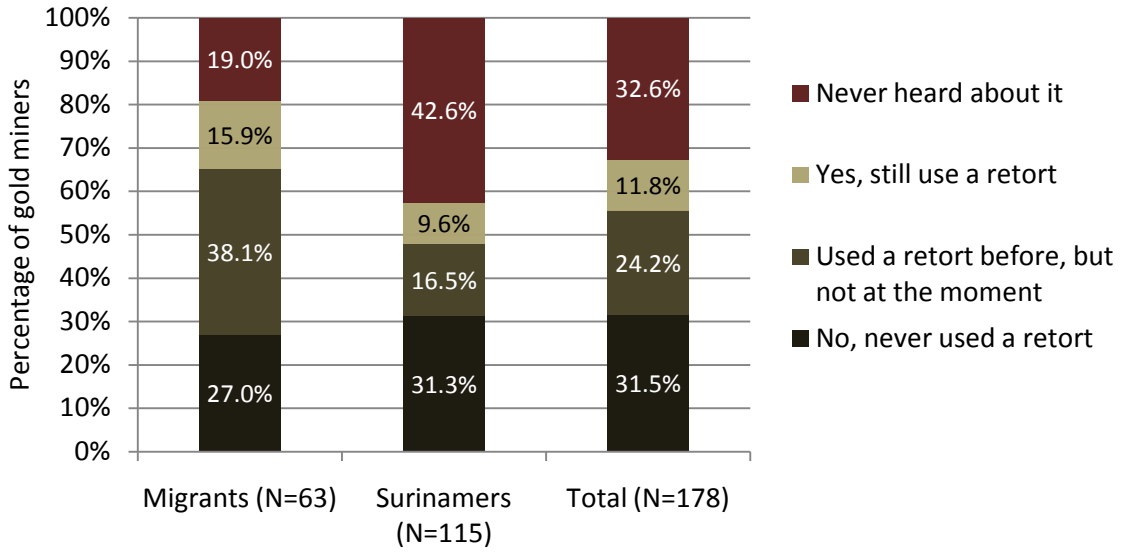
kitchen, sleeping hut, or other covered space. Still, more than one out of every ten gold miners reported that they "always" (8.9%; N=169) or sometimes (2.4%; N=169) burned the gold under a roof (often open walls). One Brazilian gold miner even said that when there was not much gold, they would burn the amalgam on the kitchen stove.

4.5 Knowledge and use of a retort

A retort is a simple, relatively inexpensive device which allows gold miners to recycle mercury when burning the gold-mercury amalgam. When asked whether they had heard about a retort, two-thirds of small-scale gold miners answered affirmatively (65.7%; N_{total}=178). Migrant gold miners were significantly more likely than Suriname miners to report that they knew what a retort was (respectively 81.0% vs. 57.4%; p<0.005) (Figure 10).

Despite knowledge of its existence, the use of a retort was not very common (Figure 10). Less than one out of every ten gold miners reported that they always or often use a retort to burn the amalgam (8.8%; N=170)[17]. Another 3.0 percent of surveyed miners reported that they "sometimes" use a retort. For example, a Brazilian equipment owner explained that he often burns the amalgam in an empty, closed barrel, with a hole cut out on the side. The recovery of mercury in this system is, in his opinion, similar to the recovery when he uses a retort (est. 80%). Another Brazilian gold miner commented that he would not use the retort when there was not much gold.

Figure 10. Responses to the question: "Have you ever used a retort?"



As compared to Suriname gold miners, migrants were more likely to report that they "always" use a retort (Surinamers: 4.5%, N_{total}=110; Migrants: 15.2%; N_{total}=59) (Figure 10). About one quarter of survey respondents had used a retort before but were not using one at the moment (24.2%; N_{total}=178). The number of years of experience in gold mining did not affect the likelihood that a gold miner was using a

[17] We suspect some over-reporting

retort. That is, the relatively more experienced gold miners were not more or less likely than other to use a retort.

In total, 36.0 percent of surveyed small-scale gold miners had experience with a retort; they had either used it before or were still making use of it (N_{total}=178; Figure 8). As compared to Suriname miners, migrant gold miners were twice as likely to have experience with a retort.

The great majority of the individuals who had experience with a retort reported that it worked extremely well and they were or had been content with it (82.8%; N_{total}=64). An important reason for liking the retort was that one would retrieve most of the mercury for re-use; according to the gold miners an estimated 80 to 90 percent. Others added that it was good because the mercury vapour does not escape, there is less pollution, and it protects the miners.

Not everyone, however, lauded the retort. We asked small-scale gold miners who either never used a retort or were not using one at the moment for the reason that they did not use one. By far the main reason for people not to use a retort is that they had never heard about it and did not know about its existence. A related comment was that the person had just never seen it in use and was not familiar with it. One miner said: “No-one has ever explained well how it works”. Among the 117 gold miners who knew of the existence of a retort, 43 individuals had used a retort before and 21 gold miners were still using one. Among those who had heard of a retort but never used one or were not using one at the moment, the most common reason to not use one was that they did not have one at the camp. It is the responsibility of the equipment owner to buy all material needed for mining and workers do not interfere in this process (Table 3).

Sixteen persons mentioned that it takes too long to burn the gold. Burning the amalgam in a retort may take, according to expert estimates, between 40 and 90 minutes per session, depending on model of the retort and amount of gold. An equipment owner added that in the case that they have a lot of gold (e.g. 1 kg), they need to divide the amalgam in two in order for it to burn well. Not only are the gold miners anxious to see the result of their work, the duration also is felt as a security risk. A Suriname gold miner commented: “It goes too slow. When you burn with fire it goes faster and you are done before the robbers arrive.”

Several gold miners responded that they just never bought a retort. One person added that gold miners are simply ‘like that’. At the moment they are about to get the gold they do not think about health and safety anymore. Other reasons were named by three or fewer persons (Table 3). The fact that the gold burned in a retort becomes very hard and difficult to divide was also mentioned as a disadvantage by three persons who still used a retort. One equipment owner explained that this problem may be avoided by placing toilet paper between layers of gold-mercury amalgam, which allows for easier breakage after burning. These and other reasons for not using a retort are listed in Table 3.

Table 3. Reasons for not using a retort among persons who had heard of a retort but were (currently) not using one (N=94).

	Number	%
We don't have one here at the camp	28	29.79%
Takes too much time	16	17.02%
Just never bought one	9	9.57%
Expensive (acquisition and/or gas for usage)	7	7.45%
Not familiar with it/don't know how it works	6	6.38%
I use little mercury/only burn small quantities of amalgam	5	5.32%
I do not have the money at the moment	3	3.19%
I do not trust these devices	2	2.13%
Just recently started here	2	2.13%
Difficult to divide the gold (it becomes hard)	2	2.13%
I had one but it broke down	2	2.13%
Not interested/laziness	2	2.13%
It has a small capacity; you need to divide the gold in pieces	2	2.13%
It does not burn all gold	2	2.13%
Not necessary for coarse gold; it requires little mercury	1	1.06%
We are not working professionally	1	1.06%
I use a centrifuge	1	1.06%
Leaves are sufficient	1	1.06%

4.6 Contact with mercury

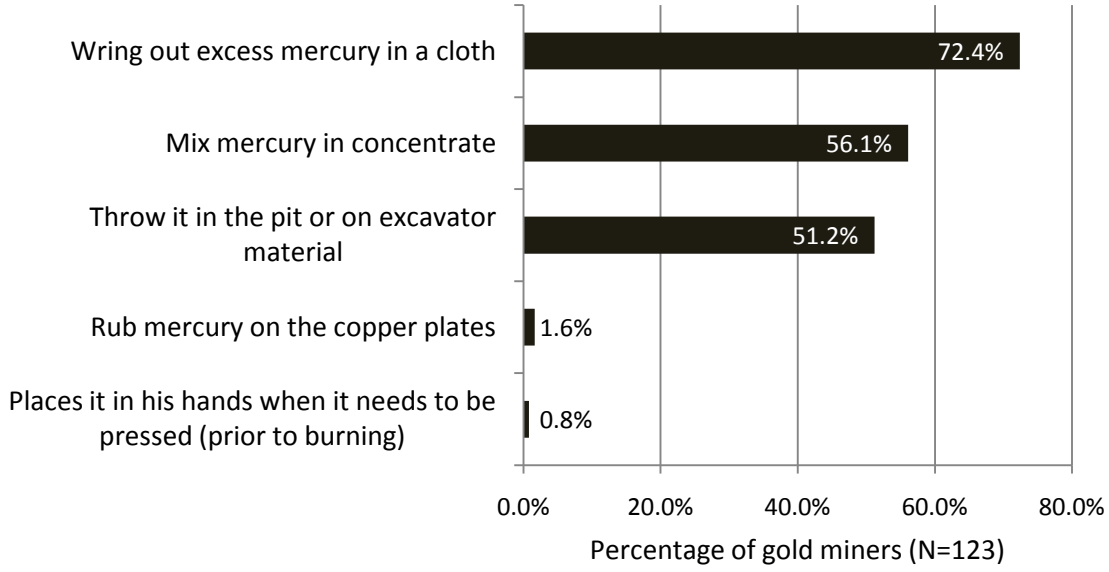
As depicted in Figures 2 and 6, small-scale gold miners come in contact with mercury in different stages of the mining process. We asked gold miners specifically about skin contact and inhalation, which are the main forms of exposure to mercury for gold miners.

The majority of gold miners who worked in teams that used mercury declared that they personally handled mercury (82%, 141 persons; N_{total}=172). Of the gold miners who personally handled mercury, 87.2 percent admitted that they also had skin contact with this substance (123 persons; N_{total}=141). There was no significant difference between Suriname and migrant miners in this regard.

Almost three-quarters of gold miners among those who reported skin contact specified that they – among others- came in contact with mercury when they squeezed excess mercury out of the concentrate (72.4%; N_{total}=123; Figure11). In this process, the gold-mercury amalgam is placed in a piece of cloth, which is squeezed so that the excess mercury is pressed through the fabric, while the gold and the amalgamated mercury remain in the bundle (Figure 2c). A Brazilian *porcentista* even joked that he squeezed out the excess mercury "in this same t-shirt that I am wearing now".

Another time that small-scale gold miners commonly have skin contact with mercury, is when washing the sluice box (56.1%; N_{total}=123). In this process, the mercury is rubbed in the concentrate, usually with bare hands (Figure 11).

Figure 11. Percentages of small-scale gold miners who report having skin contact with mercury in different phases of the mining process

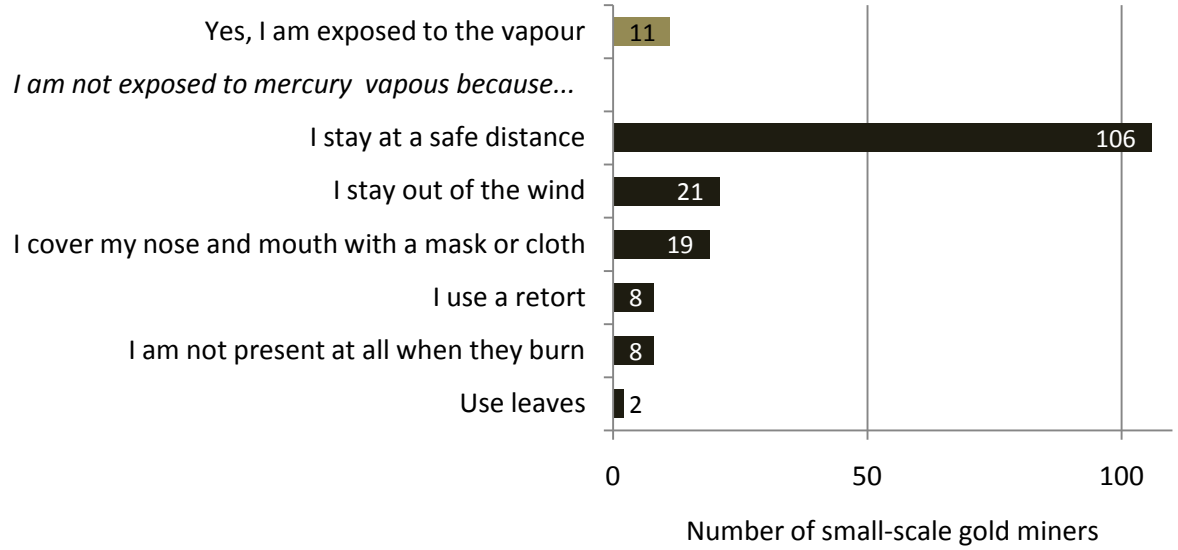


About half of the gold miners who reported skin contact with mercury said they held this substance when throwing it on the unprocessed material; in the mining pit or on the excavated heap of dirt (51.2%; N_{total}=123). Several gold miners explained that they did not have contact with mercury in this stage because they would pour some mercury in a cloth and next sweep the cloth in the direction of the dirt. Since cloth is porous, mercury drips sprinkle on the material. Others would pour mercury straight from the bottle on the unprocessed ore, or use a soft drink bottle cap to disperse it.

Skin contact with mercury is also made when teams working with a crusher rub mercury on the copper plate that is attached to the sluice box, or when miners kneed the gold mercury amalgam in the desired shape for burning. We did not explicitly ask about the latter two behaviours and this may explain the low number of individuals who reported them.

Much more dangerous than skin contact, however, is inhalation of the mercury vapour when the gold-mercury amalgam is burned. Small-scale gold miners seem to be aware of this fact. Whereas they did not take any meaningful measures to protect themselves against skin contact with mercury, they generally do make a conscious effort to stay away from the fumes. Whether they are successful in doing so could not be established, but the large majority of gold miners argued that they were not exposed to mercury vapours for a variety of reasons (Figure 12).

Figure 12. Perceptions of exposure to mercury vapour during the burning process (N_{total}=148)



The most common reason for believing that one is not exposed is that the person always stays at a (safe) distance (71.6%; N_{total}=148). However, because mercury vapours are colourless and odourless, it is difficult to determine what distance is "safe". Other people reduced their exposure to poisonous vapours by staying out of the wind direction (14.2%), covering one's nose and mouth with a mask or cloth/shirt (12.8%), and using a retort (5.4%) or leaves (1.4%) (N_{total}=148). With regard to the latter, one gold miner commented that one can also reduce exposure by changing the leaves when they turn out to be insufficient.

Only 11 small-scale gold miners acknowledged that they were exposed to mercury vapours (7.4%; N_{total}=148). Some of their clarifications included:

- "There is no way to eliminate exposure. Nevertheless, you try to get as little as possible by not standing in the wind."
- "Sometimes we run away, but sometimes you want to stay close to watch"
- "… the vapour will some way or another get on your skin."
- "I do not know it for sure, but I think so [that I am exposed]. As long as you work with it, it will be inhaled."

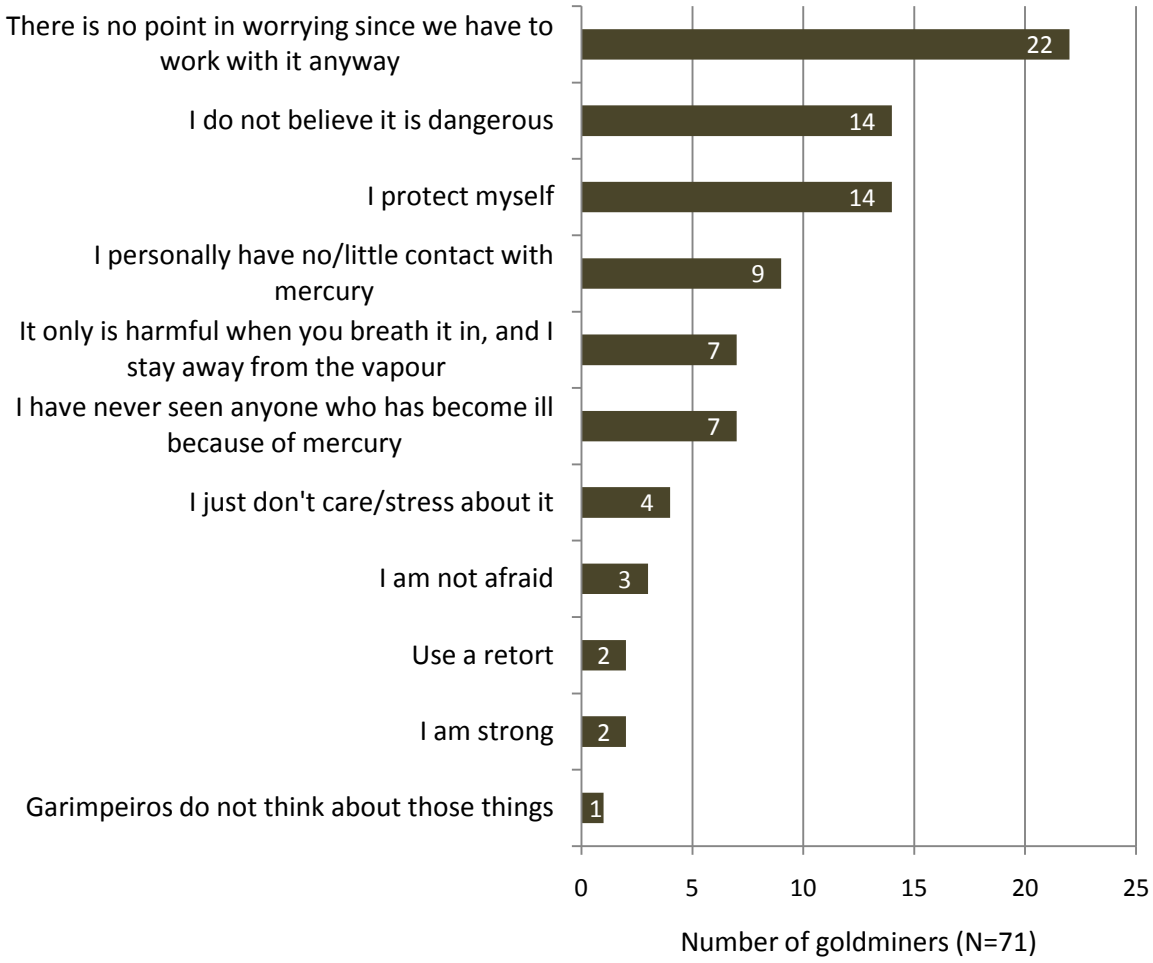
4.7 Risk perceptions with regard to mercury

We asked small-scale gold miners whether they were concerned about contact with mercury. More than half of the surveyed miners indicated that they were concerned (59.9%; N_{total}=177), with no significant difference between migrant and Suriname gold miners. Also the number of years of experience in small-scale gold mining, educational background and age did not affect whether someone was concerned about contact with mercury. Among those who were worried, the main reason for concern was the adverse health effect of mercury. They insisted that it can make you ill (57.5%); enter the skin or cause skin problems (4.7%); enter the blood (2.8%); cause cancer (0.9%); or even kill you (8.5%; N_{total}=106).

The second most made comment was that mercury is dangerous (36.8%; N_{total}=106). Some individuals specified that it is a toxic or a chemical substance. Four gold miners referred to the environmental effects of mercury; its impact on fish, water, and the general natural environment (3.8%; N_{total}=106).

Forty percent of small-scale gold miners revealed that they were not concerned about contact with mercury. The main reason for not being concerned appeared to be nonchalance (Figure 13). People said that there is no point in worrying because they have to work with mercury anyway (31.0%), that they just do not care/stress (6.3%), that they are not afraid (2.8%) and that *garimpeiros* simply do not think about those things (1 person; N_{total}=71). "Why should I be scared," another gold miner commented: "you just have to be careful."

Figure 13. Reasons why gold miners are not worried about contact with mercury (N=71)



Others doubted the health risks associated with contact with mercury. They commented that they did not believe it is dangerous (19.7%) or that they had never seen anyone who had fallen ill because of mercury (9.9%; N_{total}=71). A Brazilian gold miner said: "I have heard that you can get spots on your skin, but I have never seen it, so … "

A third primary reason for not worrying about contact with mercury was the individuals' belief that even though mercury can be dangerous, they personally would not be affected because they protect themselves (19.7%), work carefully (with a retort, no contact with mercury, no inhalation; 25.4%) or are strong (2.8%; N_{total}=71). A Suriname gold miner with more than 7 years of mining experience clarified: "Every job has its good and its bad sides. You have to know how you achieve the positive things, so for example, I stay out of the wind when burning."

One way of assessing whether gold miners have concerns about contact with mercury is to look at how they protect themselves against it. Surveyed gold miners were asked what forms of protection they used to avoid contact with mercury. Their answers are recorded in Table 4.

Table 4. Measures taken by gold miners to protect themselves against contact with mercury

	Number*	%
Use a cloth or shirt to cover nose and mouth	69	41.6%
Stay out of the wind when burning	57	34.3%
Stay at a distance when burning	35	21.1%
Nose cap/Mask	17	10.2%
Use retort	6	3.6%
Gloves	5	3.0%
Cover my head so that the mercury cannot get into my hair	3	1.8%
Wear protective clothing	1	0.6%
Cover nose and mouth with my hand	1	0.6%
Only use mercury in a special place	1	0.6%
Ensure that there is no skin contact (sprinkle mercury from cloth or bottle)	1	0.6%
Keep it separate from other items	1	0.6%
Wash body with diesel	1	0.6%
No protection	35	21.1%
	166	100%

*The numbers add up to more than 166 because some persons mentioned more than one protective measure.

One out of every five gold miners indicated that they did not use any form of protection (21.1%; N_{total}=166[18]). When miners do think of protection, the most common practice is to cover the nose and mouth with a cloth (usually the t-shirt they are wearing) (41.6%) a nose cap/mask (10.2%) or the hands (0.6%; N_{total}=166). Others only limit their contact with mercury vapour by staying at a distance when burning the amalgam (21.1%) and/or ensuring that the wind does not blow the fumes their way (34.3%; N_{total}=166). Five individuals reported the use of gloves, and three miners mentioned they covered their head -with a hat or a wet cloth- so that the vapour would not get their hair. Other "protective" measures were less common and at times quite surprising, such as washing the body with diesel.

On the other hand, mercury is also used in Afro-Suriname Winti belief system as a *tapu*; to protect oneself against evil powers. For example, people may place a small flask of mercury on the beam above

[18]twelve persons said they did not have any contact with mercury and thence the question did not apply to them

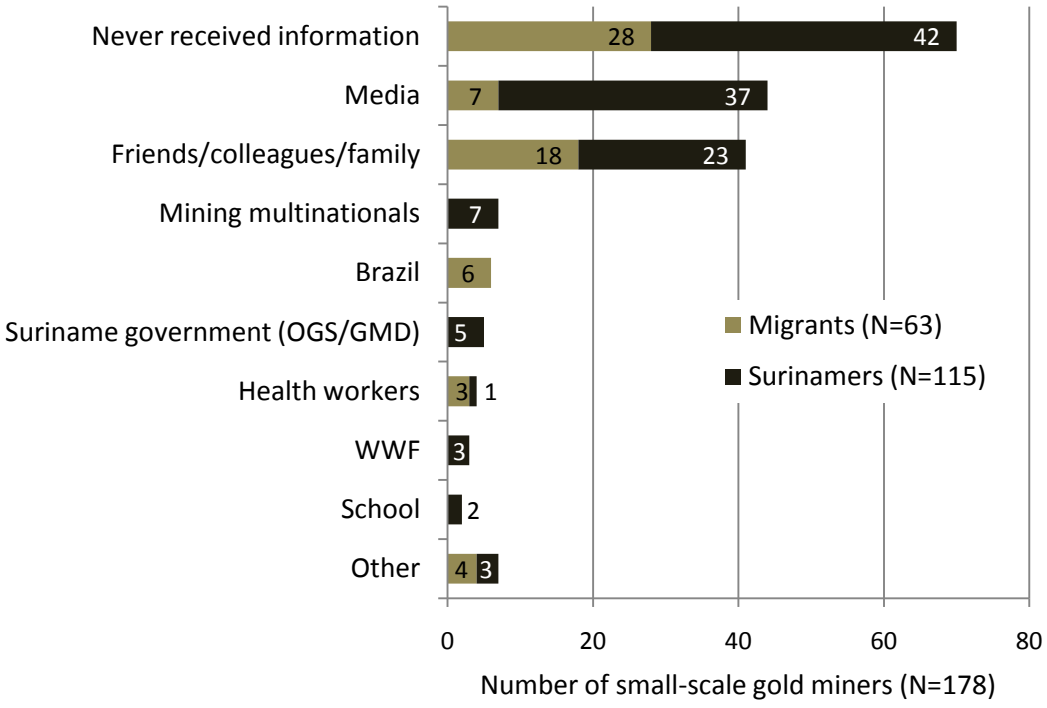
the main entrance to the home, or place a drip of mercury in a tiny container that hangs around the neck or is tied around the hips or arm. A Suriname machine owner explained that he recently drank a bottle cap of mercury as a *tapu*.

4.8 Exposure to awareness raising activities

As described in section 3.6, various governmental and non-governmental institutions in Suriname have engaged in efforts to enhance the awareness of small-scale gold miners about the risks of using mercury, and promote the use of retorts. We asked small-scale gold miners whether they had ever received information from these initiatives or similar programs elsewhere.

Nearly two out of every five gold miners declared that they had never received any information about mercury (39.3%; N_{total}=178) (Figure 14). When gold miners had received information, it was most likely to have come from the media (24.7%) or friends and colleagues (23%; N_{total}=178). Smaller groups of gold miners had been exposed to awareness raising activities from the Suriname government (mainly OGS) (2.8%), the mining multinationals Iamgold, Newmont and Suralco (5.1%) and WWF (1.7%; N_{total}=178). The data suggest that awareness activities to date have been poorly effective in reaching gold miners.

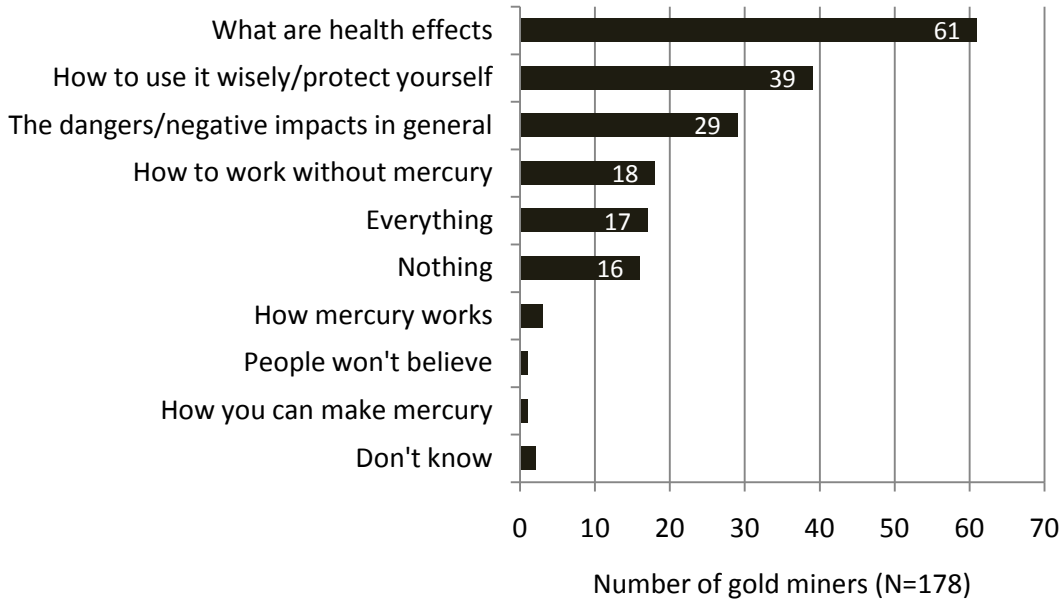
Figure 14. Sources from where gold miners had received information about mercury



Gold miners conveyed that they would welcome more information about mercury (Figure 15). The topic that was most often mentioned by interviewees as something they wanted to learn more about, was the health effects of small-scale gold mining (34.3%; N_{total}=178). “I want to know how it sits in the body,” a gold miner said: “how it feels.” A colleague from another camp conveyed: “I want to know how harmful it is, what the direct effects are, and how often you can use it before you fall ill.” “How does it work?

How does it damage the body?" asked some else. Another 16.3% of gold miners wanted to know about the dangers and negative impacts in general (N_{total}=178).

Figure 15. What mercury-related topics would you like to learn more about?



The second most mentioned issue that gold miners wanted to be informed about was how to use mercury wisely, and how to protect oneself when using it (21.9%; N_{total}=178). "What are the risks, and how can it be used without polluting the environment and harm our health?" asked one of the surveyed miners. Meanwhile others wanted to learn how to work without using mercury altogether (10.1%). A Suriname gold miner posed: "How can gold be captured without using mercury, but while getting the same amount?".

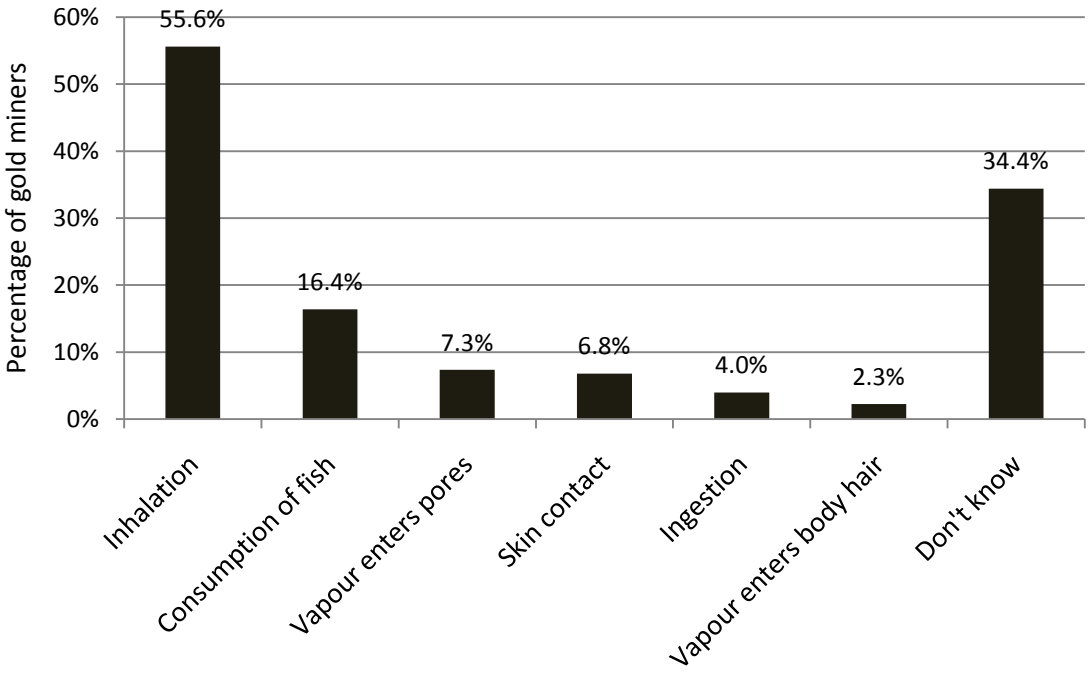
Similar numbers of gold miners wanted to know either "everything" about mercury or, in the contrary, "nothing". Those who said that they did not need any information mostly justified their answer by stating that they already knew everything or had sufficient information. Others thought providing information just would not have any effect, like the Brazilian gold miner who said: "All who work in the *garimpo* are rebels. They won't be interested. Gold is the only thing that concerns them."

Some of those who did believe that awareness raising could make a difference said that information should be straight forward and have a shock-effect. The use of visuals such as a documentary was recommended because it would more easily convince people.

4.9 Knowledge of environmental and health effects of mercury

When asked how mercury might enter the human body, just over half of surveyed gold miners mentioned inhalation of vapours (55.6%; N_{total}=177; Figure 16). Inhalation is indeed the most common cause of mercury poisoning among gold miners. The consumption of fish was the second best known source of mercury contamination, and mentioned by 16.4% of gold miners. Gold miners typically consume more meat than fish. Nevertheless, we noted gold miners with fishing gear, a fish net in an abandoned mining pit, and cooks preparing local fish, suggesting that gold mining teams also regularly consume fish from the mining area. A mining professional from the GMD confirmed that in the past year, gold miners have started to consume relatively more fish and bush meat, rather than only meat from Paramaribo (B. Paansa, Chief exploration and geology GMD, pers. com. 8/8/2014). He suggested that lower earnings in the small-scale gold mining sector may explain this shift to free local sources of protein.

Figure 16. Perceptions of gold miners about the ways in which mercury enters the body (N_{total}=177)



Four gold miners did not believe that one would ingest mercury through the consumption of fish. One gold miner remarked that in his view, the story about mercury in fish was "made up". Another gold miner similarly indicated: "It is not possible that fish eat mercury because mercury does not float." Yet another person said that he did not believe that mercury remained in the fish; it would evaporate during the cooking process.

In total 25 interviewees suggested that the mercury vapour enters the pores/skin or that mercury enters the skin upon contact. As explained in section 3, for mercury to enter the skin through the pores is difficult. For mercury vapour to enter the (arm) hair upon contact, which was mentioned by four

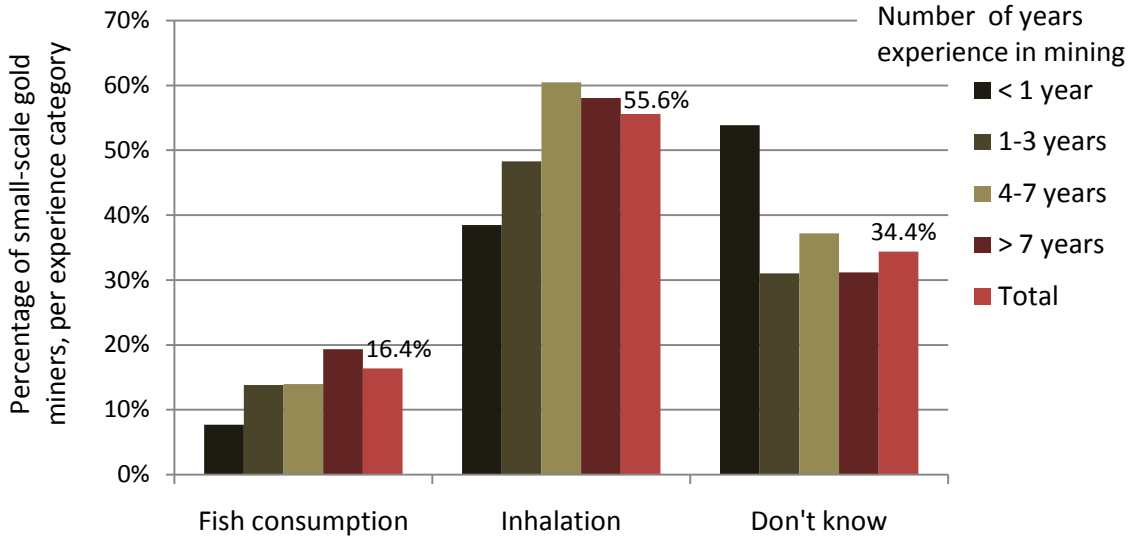
persons, is impossible. Other answers, which were all only mentioned once, were: when it enters your eye; when you have a cut; and the consumption of animals that drink water with mercury. None of these are likely sources of mercury poisoning. One third of surveyed gold miners could not name any means through which mercury affects people.

Gold miners with relatively more experience in gold mining were on average slightly better informed about the ways that mercury can affect people, but differences were not large (Figure 17). Nineteen percent of gold miners with more than 7 years experience in small-scale gold mining knew that people ingest mercury by eating contaminated fish, versus about 14 percent of miners with between one and seven years of mining experience, and 7.7 percent of those who had entered the mining business less than a year ago. About 60 percent of those with four or more years of mining experience named inhalation as a means for mercury to enter the human body, versus 48.3 percent of those with one to three years of mining experience and 38.5 percent of mining novices (<1 yr experience). On the other hand, people with little experience as small-scale gold miners were relatively more likely than others to report that they did not know by what means mercury might enter the body.

Educational achievement and age were not related to gold miners' knowledge about the ways through which mercury might get into people.

Given their limited exposure to information about mercury, it may not be surprising that gold miners' possessed little more specified knowledge of the health effects of mercury. When we asked gold miners if they knew what types of fish typically have a higher mercury content, half of the respondents said they did not know (48.3%; N_{total}=178).

Figure 17. Knowledge of the main ways through which mercury affects people, by number of years experience in the mining area (N_{total}=177)



Others provided their ideas about what types of fish may have higher mercury content. Thirty percent of surveyed gold miners correctly named certain types of piscivores such as Piranha (*Pygocentrus*

nattereri), Anjumara (*Hoplias aimara*), or Pataka (*Hoplias malabaricus*), or occasionally referred to them as a group (*roofvissen*) (N_{total}=178). People who named these fishes did not necessarily understand the movement of mercury in the food chain, but rather commented that these were the fish they caught in or near the mining area. Other referred to "large fish" (8.4%), ground feeders (5.1%), fish caught in the mining areas (4.5%), and all fish (1.7%; N_{total}=178). Answers given by just one person included: fish eating little water plants; fresh water fish and unscaled fish.

Many adverse health effects are associated with the accumulation of mercury in the body, though these vary depending on the dose, duration of exposure, route of exposure (inhalation, ingestion or dermal contact), chemical form of the mercury, and age or developmental stage of the subject (WHO 2013; see also section 3.3).Very few gold miners could name any of the effects that may be caused by mercury poisoning. When asked about it, 88.8 percent responded that they did not know (N_{total}=178). Other named a wide variety of symptoms, namely: Dirty blood, drying out, loss of hair, birth defects, brain damage, head ache, fever, swollen feet/limbs, tired/apathy/weakness, eye problems, pale skin, impotency, general body pain/feeling bad, become disabled, bruises and swellings, craziness, cancer (throat, leukaemia), rotten teeth, paralysis, deafness, blindness, dizziness, and death. Most of these symptoms can indeed be associated with certain forms of mercury contamination.

Also in response to the question "what can you do when there is too much mercury in your body?" the grand majority responded that they did not know (71.3%; N_{total}=178). Only four persons from the entire sample gave a correct answer, namely that there is no cure or that you cannot do much about it since it takes a very long time for mercury to leave the body (it has a long retention time[19]). Among those who did believe in a cure, most said one could go to the doctor for medication (12.4%) or get a blood transfusion or blood replacement (9.6%; N_{total}=178). Particularly migrant miners insisted that in Brazil, blood transfusion or replacement was a common way to treat people with mercury poisoning (20.6%; N_{total}=63). As explained in section 3.4, there is no effective medication or treatment to remove mercury from the body. Five persons indicated that one should "drink milk" to remove mercury from the body. A Suriname gold miner indicated that in order to remove mercury from the skin: "… you have to burn the skin; you need to move a lighter along the arm so that you feel the heat".

A significant proportion of gold miners had a poor understanding of the dispersion of mercury in the natural environment. More than a third of small-scale gold miners did not believe that the health of children could be affected by the use of mercury in a nearby mining area (35.4%; N_{total}=178). They often said that children were not present in the mining area or living at some distance. People who believed that children in nearby villages could be affected said that children could become ill because of the vapours, when they drink water, and when they eat fish. In fact, the latter reason is the most important risk factor for children and adults in communities surrounding mining areas.

[19] Evidence from animal studies, human studies and modelling using based on appropriate assumptions point to a half-life of inorganic mercury in human brains of several years to several decades (Rooney 2013)

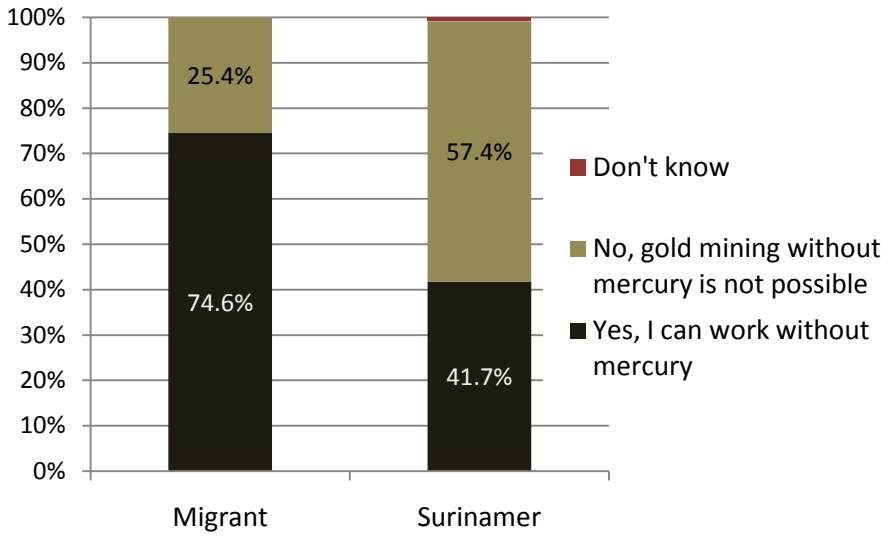
4.10 The way forward

Two thirds of small scale gold miners indicated that in their opinion, it was possible to work without mercury (63.5%;N_{total}=178). Migrant gold miners were more likely than Surinamers to insist that mining without mercury was possible (Figure 18). Brazilian gold miners with long-term experience in their profession often recounted that in the early days of their mining career, mercury was not used in Brazilian *garimpos* at all. They used the same gravitation methods, but washed the concentrate merely with water. Only in the late 1970s was mercury introduced in the mining areas, and since then the gold miners have gotten accustomed to it. Mercury had made it easier and faster to get the gold, but they believed that also without mercury one could continue mining for gold. For example, a 52-year old *porcentista* (gold labourer) we spoke with in Tumatu explained:

> "In the early days in Brazil we worked without mercury. We washed the [concentrated] material in a baté. Next, the final bit had to dry out completely. We would place that on a plate, and then throw the material up, so that the wind would blow away all the dirt[20]."

He commented that it is possible to extract gold without mercury, but "it is a lot of work and you will lose a lot."

Figure 18.The vision of migrant and Suriname miners on the possibility to mine gold without mercury.



Number of years of experience in small-scale gold mining was not significantly related to the chance that a gold miner believed that working without mercury was possible. That is, more experienced gold

[20]This is originally an old agricultural procedure of "winnowing" and has also been documented among19th century gold miners in the US (as early as 1842), South and Central America. This method was particularly used by gold miners working in arid places, to compensate for their lack of water.

miners were, on average, not more or less likely than others to say that working without mercury was possible. Neither did education affect one's belief in mercury-free mining.

Gold miners who asserted that it was possible to mine for gold without mercury, mostly said that one could just use the same methods, with the difference that one would wash the concentrate only with water (40.2%; N_{total}=112). Others indicated that it was possible with special machines (31.3%). They named the shaking table (7 persons) or a centrifuge (2 persons), but most people said they did not know the name or did not know what kind of machine. They often did say, however, that the type of machines you would need are very expensive. Several persons said that when the gold is relatively coarse, one actually does not need to use mercury. Others indicated that working with a *pew pew* one does not need mercury, but this method can only be used to find gold nuggets. It also is possible to only use a baté, but the earnings would not be high.

Those who believed that it was impossible to mine for gold without mercury clarified that the gold would be lost in the tailings/not be captured (53%; N_{total}=65) or that all the fine gold would be lost (56.1%; N_{total}=65). Others reported that: there simply is no other method; they had only learned "one style" of working (with mercury); the gold is becoming less; you won't get the amount you want; mercury helps weigh down the gold; and that mercury helps clean the gold from branches and iron.

If the government were to ban the use of mercury in small-scale gold mining, what would happen? In the opinion of the largest group of gold miners, they would just continue without mercury (Table 5). Particularly migrant miners were of the opinion that they would find a way to deal with it. A Brazilian equipment owner explained: "We would just work without mercury, because that is what we did in the olden days. Now we have gotten used to mercury. It is easier with mercury, but it is possible without it." A colleague agreed: "we would just have to adapt."

The second most provided response was that gold miners would just continue to work with mercury clandestinely (18%;N_{total}=178). The third most expressed opinion, only given by Suriname gold miners, was that the government will have to find a way for the miners to continue, for example by giving them other machines (13.5%; N_{total}=178). A Suriname miner expressed this sentiment: "If the government wants us to stop [using mercury], they have to find us another option with no disadvantages.". A slightly more positive take on this was given by a colleague: "…then we have to be assisted with new methods. It is about our own health, so we are in favour of it." A related response, also only provided by Suriname gold miners, was that the government will have to find alternative employment (1.1%; N_{total}=178).

Others expressed the expectation that many gold miners would quit working (12.4%) or, if continuing, that it would become very difficult to work and find sufficient gold (12.4%; N_{total}=178). A Suriname man explained: "Many people do not have money to buy special machines to work without mercury and others do not have the knowledge of the ancient methods, so 70 percent will quit." Particularly Suriname gold miners expected that a ban on mercury would create national problems, such as unemployment and an increase in crime (8.4%; N_{total}=178). As expressed by one of the miners: "I was a robber in the olden days, so I am going to be a robber again." Others believed that banning mercury in

gold mining would be bad for the national economy because the government would lose income if gold miners would either quit or earn less.

Particularly migrants expressed the opinion that a ban on mercury would be good for the environment, and for their own health. Some people felt ambiguous about this issue: “On the one hand it is good for health and for the environment, but on the other hand it will become difficult to find the fine gold.”

Table 5.Perceptions of gold miners with regard to the possible consequences of a ban on mercury in the small-scale gold mining sector

What do you think would happen if the government would ban mercury from small-scale gold mining?	Migrants (N=63)	Surinamers (N=115)	Total (N=178)
We will just continue without mercury/find another system	20 (31.7%)	16 (13.9%)	36 (20.2%)
Gold miners will continue to use it clandestinely	13 (20.6%)	19 (16.5%)	32 (18%)
Government must find a solution for us/give us machines	0	24 (20.9%)	24 (13.5%)
Many gold miners will quit/we cannot mine without mercury	7 (11.1%)	15 (13%)	22 (12.4%)
It would be difficult to work/find less gold	10 (15.9%)	12 (10.4%)	22 (12.4%)
It will cause problems; unemployment, crime	3 (4.8%)	12 (10.4%)	15 (8.4%)
Would be better for the environment/health	9 (14.3%)	2 (1.7%)	11 (6.2%)
If there is another system it would be good	1 (1.6%)	7 (6.1%)	8 (4.5%)
Don’t know	1 (1.6%)	3 (2.6%)	4 (2.2%)
It would be bad for the national economy	1 (1.6%)	2 (1.7%)	3 (1.7%)
Government must find alternative work for us	0	2 (1.7%)	2 (1.1%)
They have to stop the mercury company, than we will stop also	0	1 (0.9%)	1 (0.6%)
Then they should forbid other things as well; cyanide, energy drinks, fake products etc.	0	2 (1.7%)	1 (0.6%)
If it is introduced slowly we can cooperate	0	1 (0.9%)	1 (0.6%)
Then they should control the elite as well; it has to be fair	0	1 (0.9%)	-0.60%
	63 (100%)	115 (100%)	178 (100%)

One general impression that arises from Table 5 is that the migrant miners tend to be more willing to cooperate and more positive about the prospect of gold mining without mercury. The reason for this attitude may be that, as guests in the country, they did not expect too much in terms of support from the Suriname government. Moreover, they know that in their own country the use of mercury in gold mining is also restricted. Suriname gold miners, on the other hand, were more likely to expect problems and voiced the opinion that the government was responsible for finding a solution.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

We conclude that conditions in Suriname allow for excessive and uncontrolled use of mercury in gold mining and related spillage of mercury in the natural environment. This situation elevates the risks of adverse health effects not only in Suriname but also -due to the North East trade-wind - in neighbouring Guyana and Northwest Brazil. What are these conditions?

In the first place, partly due to omissions in the regulatory framework and fragmentation of government responsibilities across departments, there is no clear unidirectional policy on mercury or control on the sale and use of this toxic metal. Instead, Suriname has adapted a policy of tolerance (*gedoogbeleid*) which permits the unrestricted use of and trade in mercury for small-scale gold mining purposes, without any form of protection of people and the natural environment. Secondly, mercury is cheap and readily available in Paramaribo and the gold mining areas. Based on the conservative estimate of two units of mercury to produce one unit of gold, we find that mercury costs less than one percent of the earnings. In other words, there are few reasons to economize on mercury.

Third, in part because of the previous points, gold miners liberally use mercury in different stages of the gold mining process. They apply mercury in the concentration phase, where it may be contained, but also whole ore amalgamation is common. In fact, some miners habitually add a daily amount (e.g. 50g) of mercury to the excavated material, particularly when the gold is fine grained. A significant share of this mercury probably flows right through the sluice box to end up in the tailings -either amalgamated or in volatile form.

Fourth, few gold miners consistently use a retort for recycling mercury during burning. Many gold miners do not even know of its existence and those who do may find that the retort takes up too much time, thus increasing vulnerability to criminal assaults. Others just don't care and –given the lack of regulation and easy access to mercury- why should they?

And finally, aggravating the previous points, knowledge and awareness of the risks related to mercury use are suboptimal. Apart from a general perception that mercury is "dangerous", gold miners proved to be poorly informed about the ways through which mercury can affect people, its health effects and protective measures. Furthermore, few gold miners were knowledgeable about mercury-free gold mining methods other than continuing as usual but without mercury, yet at the expense of their earnings.

In terms of knowledge the study also showed that gold miners are unaware and unconcerned about the impacts of their use of mercury on the health of people in nearby communities, or even further away. They perceive gold mining as a local activity with local impact, and poorly conceptualize the time and geographic scale of mining impacts.

Experience with malaria and HIV prevention programs has taught us that improved knowledge does not necessarily produce more responsible behaviour. For example, in a recent study on adherence to malaria treatment among small-scale gold miners, we concluded that: "what people know is not consistent with what they do" (Heemskerk and Duijves 2013). Hence simply providing more information to gold miners has little effect as a strategy to reduce or eliminate the use of mercury in gold mining if such a program is not accompanied by other policy measures. A Suriname gold miner even commented: "Many people won't believe it. Instead of first explaining everything, it is better to just prohibit its use, and throw those who still use it in prison."

In fact, a combination of facilitating conditions (laws and regulations, price, attitude, access to alternative techniques, and awareness) need to be addressed in order for any intervention measure to be effective. For example, a mere prohibition of mercury will drive the price up to the benefit of the mercury dealers but may not necessarily reduce the mercury flow. In Indonesia, it was found that a doubling of the price of mercury ultimately became an incentive for recycling, but only after affordable mercury recycling technology had been made available by the Global Mercury Project (Telmer and Veiga 2009; see the same document for more examples).

Earlier on we already argued that, given the popularity of mercury as a cheap, effective and readily available aid to extract gold, policy interventions may be most effective if they initially seek to reduce mercury consumption, rather than immediately aim for the total elimination of mercury use. The introduction of conservation practises like the use of retorts and mercury re-activation or cleaning can reduce mercury consumption by 50 to 90% and it does not require gold miners to purchase expensive equipment or make drastic changes to their habitual work. On the contrary, reduced mercury consumption may benefit gold miners because it can increase their profits. This argument is in line with the policy vision of the Suriname government (G. Dompig, head OGS management team, pers.com. 26/05/2014; see also NIMOS activities matrix in the draft Minamata roadmap document). The stepwise reduction of mercury in small-scale gold mining can be a first stage of a broader policy aimed at a complete ban on mercury in small-scale gold mining by a to-be-determined target date.

In terms of the reduction of mercury losses, the present study suggests that there are two main areas where huge improvements are possible. In the first place, almost three-quarters of gold miners apply whole ore amalgamation. This practice requires vast amounts of mercury; a large share of which is spilled into the natural environment. If gold miners can be motivated to use mercury only on the gravity concentrate, this would reduce mercury consumption by several factors. Telmer and Veiga (2009) estimate that stopping whole ore amalgamation can reduce mercury consumption by 90%.

Secondly, insufficient recycling of mercury takes place. More than three quarters of surveyed gold miners indicated that they cover the gold pan with leaves when burning the amalgam. However, as compared to a retort, leaves are likely less efficient means to recapture mercury. Moreover, some of the mining teams simply discarded the leaves with recaptured mercury attached to it into the forest, thus eliminating their possibly conservationist function. We have not located any study that provides information about the efficiency of leaves in recapturing mercury and this is an issue that should be investigated.

Less than one out of every ten gold miners reported that they always or often used a retort to burn the amalgam. The use of a retort is a relatively simple adaptation of the general mining process, and the device is inexpensive. Telmer and Veiga (2009) estimate that if retorts (and fume hoods for gold shops) are adopted by any singular small-scale gold mining site, immediate emissions to the atmosphere can be reasonably reduced by 90%.

In terms of recycling, it is known that the effectiveness of the liquid mercury is reduced as it becomes oxidized and contaminated with impurities (Telmer and Veiga 2009). Mercury typically performs worse after 3 or 4 uses, and so it is discarded. Through a process called "re-activation" mercury can be cleaned for effective re-use. An operation that adopts mercury re-activation or cleaning methods can reduce mercury consumption by half (ibid.). We have not heard of any small-scale gold miners in Suriname who cleaned mercury. Training gold miners in mercury re-activation may therefore be another relatively simple way to reduce mercury consumption.

Finally, an integrated approach to the reduction or eventual elimination of mercury from the small-scale gold mines, which may be effectively supported by awareness activities, requires the commitment of many different departments in government. The current fragmentation of government services and responsibilities in relation to mercury use in small-scale gold mining threatens to paralyze such efforts. The Suriname government is aware of the existing situation and there is political support to change it. The roadmap produced by NIMOS, which should guide the country to compliance with the Minamata convention regulations, provides common goals and a shared direction. Furthermore, the installation of a national mercury platform helps to get the main stakeholders around the table, and produce shared, evidence-based policy and related actions aimed at reducing mercury consumption. By providing field information about the realities surrounding mercury use in Suriname's small-scale gold mining areas we hope that this study may contribute to the formulation of appropriate intervention strategies.

5.2 Recommendations

Considering:

1. That small-scale gold mining is the largest source of mercury release in the natural environment and hence poses a public health risk;
2. That the general aim of this study was to record the knowledge, attitudes and practices with regard to mercury among small-scale gold miners working in Suriname;
3. Present efforts by the Suriname government and non-governmental organizations to reduce mercury consumption in small-scale gold mining, including the Minamata road map; and
4. The data collected in the framework of this consultancy and our key findings reported here above

We insist that mercury reduction intervention efforts are direly needed in small-scale gold mining areas.

In this context, we organized our recommendations in four sections: quick wins, outreach and policy. "Quick wins" are a list of specific activities that are viewed as something that can be done with little effort and can normally be done in a short period of time (<6 months). "Outreach" refers to

recommendations aimed at improving gold miners' access to alternative mining technologies. Under this heading we also list the areas where improved knowledge is most direly needed and identify appropriate organizations for communication strategies. "Policy" related recommendations are meant to strengthen the regulatory framework and organizations.

Based on our study results we recommend the following **quick wins**:

1) *Oblige the use of retorts in small-scale gold mining and make concession title holders responsible for control thereof*. The largest share of small-scale gold miners works on the concession of a legal concession title holder. The concession title holders have staff that go around to collect a percentage share of the earnings. For this reason they usually are present during the final concentration phase and burning, and hence can impose the use of a retort on the equipment owner. The Suriname government (GMD or Commission OGS) can perform random unannounced control visits and, in the case of non-compliance, take appropriate measures against <u>both</u> the equipment owner and the concession title holder.
2) *Research ways to reduce the burning time for retorts*, provided that the duration and related security risks was an important concern about this device. Solutions for other disadvantages of the retort (e.g. gold becomes 'hard') should also be explored. Such research would involve consultations with international small-scale gold mining experts, a review of relevant studies about retorts, and experiments with different retort designs and heat sources. The GMD and ADEK University could collaborate in these efforts, with support of SEMIF.
3) *Analyze the efficiency of leaves in re-capturing mercury during the burning phase.* Many gold miners cover the baté with leaves when burning gold. If this turns out to be an efficient method to recapture mercury it is worthwhile to seek ways to maximize the potential of this technique, as it is easier to promote existing practices than to introduce relatively new technology.
4) Once significant results have been achieved under 1), 2) and 3) these should be *presented to the small-scale gold miners' communities*. In our experience, many small-scale gold miners want to learn and appreciate efforts to provide information. Moreover we also found that many gold miners had never seen a retort being used. Experiences in other countries suggest that gold miners are willing to adapt their methods if they see direct economic benefits. Their health and that of other people is often a lesser concern.
5) *More field presence and regular inspections by the relevant authorities (GMD, OGS) are imperative.* It is unlikely that small-scale gold miners will stop the excessive use of mercury without outreach in small-scale gold mining communities, some degree of top-down control, and punishment of perpetrators (mining equipment owner and concession title holders).
6) *Provide a short (1 day) training to field workers of relevant government institutes on the health effects of mercury.* The results show that understanding of the health effects of mercury are poorly understood by small-scale gold miners. We also found that in one-on-one conversations with small-scale gold miners, there were many questions about these issues. Regular field visits to small-scale gold mining areas would be an excellent opportunity for GMD and Commission OGS staff to provide, in an informal way, accurate information to gold miners.

7) Use the opportunities offered by the Suriname Environmental and Mining Foundation (SEMIF)[21], the UNDP small Grants Programme and other donor programs to finance the various suggested interventions. SEMIF, for example, has funds available for projects aimed at improving the sustainability of the small-scale gold mining sector, but there are hardly any project applications. If the capacity to write project proposals is scarce within government departments, consultants can be hired to perform that work.

Outreach

8) *Deliver clear and accurate information about the main ways that mercury affects people, the health effects of mercury, and measures to reduce mercury consumption by quitting whole ore amalgamation and recycling, as part of an integrated policy on mercury use in the small-scale gold mining sector*. The results show that the majority of small-scale gold miners have poor understanding of the possible health effects of mercury and would like to learn about them. The results also show that many gold miners do not know about the retort and have never seen one in use. While we did not ask about cleaning mercury, we also suspect that re-activation methods are relatively unknown. Knowledge about these issues has a greater chance to drive behavioural change if it is part of a package of policy interventions that provide additional incentives for reducing mercury consumption.
9) *Discourage whole ore amalgamation* by a combination of support measures/guidance (GMD, OGS) and accurate technical information showing that whole ore amalgamation reduces profits as it costs more money while it does not capture more gold. Because it is virtually impossible to control whether gold miners use whole ore amalgamation, changes of this habit rely mostly on gold miners' own wish to reduce mercury spillage. Concession title holders can be held responsible for pollution on their concessions, for example by obliging them to pay for training and awareness activities.
10) The results suggest that as long as the cost of mercury is only a small fraction of the total operational expenses, gold miners may not pro-actively search for ways to economize on mercury use. *Elevating the price of mercury by stricter control on import and trade* may produce an incentive for gold miners to recycle mercury and stop whole ore amalgamation.
11) *Reinforce trust in government entities such as the GMD and the Commission OGS as organizations that provide services to small-scale gold miners*, regardless of the miners' legal status. Regular field visits by staff of these offices and informal conversations and advice to gold miners may help to establish a respectful working relationship as a basis for the implementation of government interventions in the sector.
12) *Provide information to small-scale gold miners in a way that is easy to understand, interesting, culturally appropriate and visual, and based on proven outreach methods.* There is a lot of existing outreach material to inform small-scale gold miners about various aspects of mercury use (risks, reduction of consumption, recycling, re-activation), among others from the GEF Global Mercury Project. These materials can be used as a basis for the development of a Suriname specific

[21] SEMIF (est. 2008) SEMIF is a foundation that manages a fund which Iamgold is obliged to keep in gold with the Royal Canadian Mint of Canada. This fund is intended for the development of Suriname's gold sector.

outreach campaign. Given the limited educational achievement of many small-scale gold miners, the use of attractive visuals is imperative. GMD, OGS or other organizations could start with making an inventory of existing materials and the development of a Suriname "mercury reduction tool kit", possible with the support of NGOs.

13) *Promoting alternative methods as wise business decisions.* Acknowledge that gold miners are businessmen and women seeking to obtain maximal profit by minimizing their expenses and maximizing their profit. The environment is not a main (if any) concern and even personal and workers' health is not a primary issue.
14) *The non-mining members of affected communities should become part of the dialogue with gold miners about alternative mining methods.* Riverside communities often reap direct and indirect short-term economic benefits from small-scale gold mining, but in the long run nearby mining will produce health problems and destroy future subsistence activities. The members of affected communities must be well informed about these impacts so that they can take better informed decisions in their negotiations with small-scale gold miners.
15) *Learn from outreach activities from other Suriname government programs and collaborate with these programs where possible*. For example, the Ministry of Health Bureau of Public Health (BOG) Malaria Program has established trust and respect among small-scale gold miners, as well as a logistic network to reach the miners. Given their association with public health activities, the Malaria Program would be an excellent partner organization to provide information about mercury related health effects to small-scale gold miners.
16) *Learn from other countries that have ratified the Minamata Conventions,* such as neighbouring Guyana. Particularly considering the transboundary nature of mercury contamination, it makes sense to design shared solutions.

Policy

17) *Ratify the Minamata Convention* and use this Convention as a guideline for the development of a widely supported action plan to phase out mercury. The *NIMOS Roadmap for Implementation of the Minamata Convention* provides a skeleton for such an action plan, but it lacks hard timelines and appointed responsibilities. For example, what is the (realistic) target date for a complete ban on mercury in small-scale gold mining (if such is desired), what is the target date for informing stakeholders about this date, and who is or are responsible for informing the relevant parties?
18) *Based on stakeholder consultations and input from international experts, pinpoint a realistic target date for the complete elimination of mercury from small-scale gold mining*. All stakeholders including small-scale gold miners should be informed well in advance, so that they can prepare and take their responsibilities. For small-scale gold miners, adjustments would include seeking access to loans to finance mercury free technology. The Suriname government can assist in facilitating such access.
19) *Install a cross-sectoral platform dedicated to reducing and phasing out mercury use in the gold mining sector.* This platform should consist of, at least, NIMOS, OGS/GMD, representatives from the health sector (e.g. Ministry of Health, BOG), scientists/researchers (e.g. toxicologists, social scientists), small-scale gold mining experts, the Ministry of ATM, NGOs and legal experts. The

goals of this network should include: (a) to improve coherence between the activities of different institutions, (b) improve the efficiency and actual outcomes of interventions by governmental and non-governmental organizations, and (c) strengthen national capacity.

20) Pass a State Decree (Staatsbesluit - SB) *or Presidential Decision* (Presidentieel Besluit -PB) *to make the use of retorts in small-scale gold mining obligatory, and make concession title holders responsible for control thereof* (see 1). An all encompassing law to regulate mercury use will take some time design and be approved but this small measure maybe faster to take effect and can already make a big difference.

21) *Improve and update environmental legislation*, as proposed in the "Activities Matrix" of NIMOS' draft roadmap towards compliance with the Minamata guidelines. Directly applicable to small-scale gold miners are NIMOS' recommendations to approve of the Environmental Framework Act and act towards a legal mandate with regard to mercury release in the environment.

22) *Perform regular monitoring and control.* Policy measures and regulations do not make sense if there is neither control on compliance nor enforcement in dealing with non-compliance (see also NIMOS draft "Activities Matrix").

23) *Making mining concession titles available to registered small-scale gold miners*, preferably in smaller parcels, will make it more reasonable for small-scale gold miners to invest in cleaner mining methods and facilitate monitoring and control. Present efforts by the Commission OGS to provide gold miners with such titles in controlled miners' zones are a great first step, but at present only apply to a very small percentage share of gold miners. Stricter enforcement of the Mining Decree[22] will make mining lands available for parcelling out to small-scale gold miners.

24) *Work with the Brazilian embassy to motivate Brazilians in Suriname to comply with the regulations for legal residency in Suriname*. Undocumented migrant gold miners are afraid of government representatives, and hence difficult to reach for outreach activities and monitoring.Suriname's2014 general pardon for migrants without legal residency was a grand government gesture, however, only 139 Brazilians came forward to register during this period (versus 1340 Chinese and 632 Haitians; Unpublished data Vreemdelingenzaken, 2014). Opportunities such as a general pardon should be publicised in the gold mining areas.

[22]For example, the concession titles of concessionaries that do not comply with the Mining Decree could be withdrawn. Furthermore, the Mining Decree requires the owners of reconnaissance and exploration concessions to reject part of those concessions after a certain period, but this regulation is seldom enforced.

REFERENCES

Asano, S., K. Eto, E. Kurisaki, H. Gunji, K. Hiraiwa, M. Sato, H. Sato, M. Hasuike, N. Hagiwara and H. Wakasa (2000) Review article: acute inorganic mercury vapor inhalation poisoning. *Pathology International* 50(3):169-74.

Centers for Disease Control and Prevention (CDC) (2013). MERCURY (ELEMENTAL) : Lung Damaging Agent. Web source. URL: http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750021.html Date: June 18, 2013, Accessed: 16 July 2014

Colchester, Marcus, Jean La Rose and Kid James (2002). Mining and Amerindians in Guyana. Final report of the APA/NSI project on 'Exploring Indigenous Perspective on Consultation and Engagement within the Mining Sector in Latin America and the Caribbean'. Ottawa, CA: The North-South Institute.

Cordier S., M. Garel, L. Mandereau, H. Morcel, P. Doineau, S. Gosme-Seguret S, et al. (2002) Neurodevelopmental investigations among methylmercury exposed children in French Guiana. *Environmental Research* 89:1-11.

Dagblad Suriname (2013). Arun Jadoenath Missier: 'Verboden kwik is op negatieve lijst'. Issue of 22-01-2013. Accessed online 15 July 2014.

De Theije, M. (2009).1st Report / Evaluation of NEMS 1. Unpublished consultancy report. Paramaribo, Suriname.

Deviezencommissie (2014). Overzicht goudexport 2013. In: *De Ware Tijd*. Vrijdag 28 February 2014. Page C3.

Government of Suriname (2003).Wet Goederenverkeer(SB. 2003 no. 58).

Government of Suriname (2003). Besluit Negatieve Lijst 2003 (S.B. 2003 no. 74).

Grandjean, Philippe, Roberta F. White, Anne Nielsen, David Cleary, and Elisabeth C. de Oliveira Santos (1999). Methylmercury Neurotoxicity in Amazonian Children Downstream from Gold Mining.*Environmental Health Perspectives* 107(7):587-591

Griesbauer, L. (2007).Mercury in the Body and Health Effects. In: Methylmercury Contamination in Fish and Shellfish. Internet article. URL: http://www.csa.com/discoveryguides/mercury/review4.php

Hays, Phillip, USGS and Rickford Vieira (Undated). Mercury Contamination, A Legacy to Handicap a Generation. WWF Guianas Regional Program Office Technical Paper series #2

Heemskerk, M. and C. Duijves (2013).Study on the knowledge, attitudes and practices of malaria and malaria treatment in the small-scale gold mining sector in Suriname. Submitted to the US Agency for International Development by the Systems for Improved Access to Pharmaceuticals and Services (SIAPS) Program. Arlington, VA: Management Sciences for Health.

Heemskerk, M. and M. Olivieira (2003). Perceptions of small-scale gold mining impacts: Results from focus group discussions in mining camps and affected communities. Tapanahonie & Brokopondo Regions, Suriname. Report for WWF-Guianas. December 2003.

Heemskerk, M. and M. Olivieira. 2004. Perceptions of small-scale gold mining impacts II. A survey in mining camps and affected communities in Suriname and French Guiana. WWF Guianas project FG64. Paramaribo, Suriname. March 31, 2004

INVS (1999). Exposition au mercure de la population amérindienne Wayana de Guyane. Enquête alimentaire. http://www.invs.sante.fr/publications/mercure/editorial.html

NIMOS (2014). Activities Matrix Mercury Free Environment. Strategy matrix Policy document & Roadmap for Implementation of Minamata Convention. Policy report. Nationaal Instituut voor Milieu en Ontwikkeling Suriname, Paramaribo, Suriname.

Ouboter P.E., G.A. Landburg, J.H. Quik, J.H. Mol and F. van der Lugt (2012). Mercury levels in pristine and gold mining impacted aquatic ecosystems of Suriname, South America. *Ambio* 41(8):873-82.

Ouboter, P.E. and G.A. Landburg (2010). Mercury poisoning: A Threat to Brownsweg Villagers. Paramaribo, SU: NZCS/CMO, Anton de Kom University of Suriname

Passos, C. J. S. and D. Mergler (2008). Human mercury exposure and adverse health effects in the Amazon: a review. *Cadernos Saúde Pública* 24 (4). Online journal. URL: http://dx.doi.org/10.1590/S0102-311X2008001600004

Peplow, Daniel and Sarah Augustine (2007?). Community-led assessment of risk from exposure to mercury by native Amerindian Wayana in southeast Suriname. Available online at: http://downloads.mts.hindawi.com/MTS-Files/JEPH/papers/HEOI/674596.v3.pdf?AWSAccessKeyId=0CX53QQSTHRYZZQRKA02&Expires=1318542285&Signature=HcO0M3bSC%2FfTTGTfx6WFDC6xlSo%3D

Rooney, James P.K. (2013). The retention time of inorganic mercury in the brain — A systematic review of the evidence. Invited Review Article*. Toxicology and Applied Pharmacology*. 274 (3): 425–435

Sousa, Rodolfo N. and Marcello M. Veiga (2007). Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies. Global Mercury Programme and United Nations Industrial Development Organization. Itaituba, State of Pará, Brazil

Telmer, Kevin H. and Marcello M. Veiga (2009). World Emissions of Mercury from Artisanal and Small Scale Gold Mining. Chapter 6, in: N. Pirrone and R. Mason (eds.), Mercury Fate and Transport in the Global Atmosphere. Springer Science and Business Media, LLC, Pp 131-172

Tuolumne county historical society (Undated). Summary of Gold Mining Techniques in Western United States 1842 – 1996 Internet document. Last updated 2013. Accessed 7 August 2014.URL: http://www.tchistory.org/tchistory/more_gold.htm

United Nations Environmental Program (UNEP (2014). Minamata Convention on Mercury Countries. Web site. Last updated 2014. Accessed 9 August 2014. URL: http://www.mercuryconvention.org/Countries/tabid/3428/Default.aspx

Veiga, M.M. (1997). Introducing new technologies for abatement of global mercury pollution in Latin America. Rio de Janeiro: UNIDO/University of British Columbia/Center for Mineral Technology.

Veiga, M.M., S.M. Metcalf, R. Baker, B. Klein, G. Davis, A. Bamber, S.J. Siegel, and P. Singo (2006). Manual for Training Artisanal and Small-Scale Gold Miners. Global Mercury Project. GEF/UNDP/UNIDO, Vienna, Austria.

Vieira, R. (2006) Mercury-free gold mining technologies: possibilities for adoption in the Guianas. *Journal of Cleaner Production* 14(3-4): 448-454

World Health Organization (WHO) (2013).Mercury and health. Fact sheet N°361. Internet source. URL: http://www.who.int/mediacentre/factsheets/fs361/en/. Date: September 2013. Accessed: 16 July 2014.

Annex I. Mercury contamination in Suriname and its neighbouring countries. Facts and figures

Fact	Suriname	Brazil	French Guiana	Guyana
Legal status of mercury	No legal regulations concerning the use of mercury. The import mercury is restricted and by permit only	Use of mercury in SSGM is not prohibited but its use is regulated	Prohibited in legal mines since 2006	The Mining Act 1989 dictates regulations for mercury acquisition, use in the mining cycle, handling, workers' protection and storage.[7]
Hg in mine tailings	No data obtained	4 to 300 ppm Hg (mg/kg)[1]	No data obtained	No data obtained
Hg in river sediments****	98% of sediment samples had a mercury level well above global background levels of 0.01–0.05 µg/g (53 sites). Sediments in the gold mining area are usually near or above the Canadian standard	7 to 14 ppm Hg[1]	No data obtained	No data obtained
Hg in fish*	In 53 localities, 41 % of piscivores had a mercury level above the EU standard for human consumption of 0.5 µg/g and 15 % above the US EPA standard for human consumption of 1 µg/g	0.5 mg of total Hg/kg of fish[1]	Up to 1,62 mg/kg[2]	57% of tested carnivorous fishes had elevated mercury levels above the maximum WHO level (0.5 µg/g)[8]
Hg in mining populations**	No data obtained	Levels up to 78.5 µg Hg/g of creatinine*** in urine	No data obtained	No data obtained
Hg in river communities**	Mean hair Hg concentration in Wayana Indigenous communities Apetina: 14 µg/g and Kawemhakan: 8 µg/g[3]	Mean Hg-hair values recorded in 21 studies ranged from 8.0 to 38.6 µg/g[4]	Mean of 11,4 µg/g in hair in Wayana Indigenous communities[2]	Hair-Hg levels in Indigenous communities ranged from 2-22 µg/g[7]; In one community 96% of pop. displayed Hg-hair values >10 µg/g[7].
Clinical/ neurological symptoms observed?	>1/3 of persons in Wayana communities experienced minor effects of mercury intoxications (e.g. headaches and pain and tingling in hands and feet); 3 women exhibited abnormal neurological performance[3]	Symptoms of mercury intoxication observed in inhabitants of mining communities, and in children in communities downstream of mining areas[1, 4, 6].	Neurodevelopmental effects recorded in exposed children[5]	No data obtained

* European Union (2002) standard for mercury levels in fish for human consumption is 0.5 µg/g (EC 2002); US EPA (1994) standard for human consumption is 1 µg/g−1 (US EPA 1994).

** WHO safe standards for mercury levels in humans: 10 µg/g

*** Normal Hg levels in urine are below 5 µg Hg/g creatinine

**** Canadian Interim Sediment Quality Guideline for Protection of Aquatic Life: 0.17 µg g−1 soil

Sources

1. Sousa and Veiga 2007
2. InVS 1997
3. Peplow and Augustine 2007
4. Passos and Mergler 2008
5. Cordier et al. 2002
6. Grandjean et al. 1999
7. Colchester et al. 2002
8. Hays et al, undated

Annex II. Mercury Questionnaire

Inclusion of interviewee: *Ask the below question to determine whether the person should be included/ continue to be interviewed, or not*
Do you work as a small-scale gold miner, mine owner or mine supervisor?
1. Yes 2. No (Participant is not part of the target group. Discontinue the interview)

Date: _____ Location: _____

1. Gender (circle) : 0 = Female 1 = Male

2. What is your date of birth (insert: day/month/year) :**. . / . . / . . . .**

3. Where were you born?
   1. Suriname 2. Brazil 3. Guyana 4. French Guiana 5. China 6. Other: …….

4. Is this mining area part of the environment that you call 'home'?
   0. No 1. Yes

5. What do you do in the mining area at this moment (Circle all that apply)
   1. Pit worker/laborer 2. Machine owner 3. Mine supervisor 4. Other: _____

6. How long have you been working in gold mining (either in Suriname or abroad)?
   1. < 1 year 2.1-3 years 3.4-7 years 4.> 7 years

7. How many years of formal education, starting from grade 1 of elementary school, have you completed? _____

8. When you and your team mine for gold, do you use mercury to get the gold at some point in the mining cycle (e.g. during mining, washing, concentration, etc.)?
   0. No, GO TO 25 1. Yes 2.Don't know, GO TO 25

9. What is the benefit of using mercury? How does it help you?
   1. It captures the gold
   2. It allows us to also capture the fine gold
   3. Other: …….
   4. Don't know

When and how do you and your team apply the mercury?	Yes, always	Yes, sometimes	No, never	Don't know
10. We throw mercury in the pit				
11. We place mercury in the sluicebox while mining				
12. We place mercury in the sluicebox when we wash the sluicebox				
13. We only use mercury to wash the concentrate in a bucket or barrel				
14. Apply mercury in an enclosed location with cement floors, where it cannot seep into the environment?				
15. We use mercury on another moment in the mining cycle, namely: ……				

How does your mining team burn the gold-mercury amalgam?	Yes, always	No, never	Yes, sometimes	Don't know	N.A.
16. On a fire					
17. With a burner					
18. In a baté covered with leafs					
19. In a closed space, e.g. kitchen					
20. In a retort					

21. Do you personally handle mercury?
    1. Yes 0. No, go to …… 25

22. When you handle mercury, do you have skin contact with mercury?
    1. Yes 0. No

23. How do you have skin contact with mercury? (CIRCLE ALL THAT APPLY)
    1. Not applicable
    2. Yes when I throw it in the mining pit
    3. Yes, when I rub it in the concentrate (e.g. in the sluice box or bucker/barrel)
    4. Yes, when I wring out excess mercury in a cloth prior to burning
    5. Other: ……..

24. When you handle mercury, are you exposed to fumes?
    1. No, I stay at a safe distance from the place where we burn
    2. No, I am not present at all when they burn
    3. Yes, I like to watch
    4. Other: ……..
    5. Don't know

25. Are you concerned about being in contact with mercury; is it something you would want to avoid?
    1. Yes, it worries me 3. Don't know
    2. No I am not worried, GO TO 27 4. Other: ……

26. Why are you worried about contact with mercury? CIRCLE ALL THAT APPLY
    1. It can make you ill 3. Don't know
    2. It is dangerous 4. Other: ……

GO TO 28

27. Why are you not worried about contact with mercury CIRCLE ALL THAT APPLY
    1. I protect myself
    2. I have never seen anyone getting ill from using mercury
    3. I do not believe that it is dangerous
    4. We need to use it so there is no point in worrying
    5. Other: ……

28. How do you protect yourself when using mercury? CIRCLE ALL THAT APPLY
    1. No protection 4. Make sure the wind blows the fumes away
    2. Cloth covering mouth and nose 5. N.A. I do not handle or get close to mercury
    3. Wearing gloves 6. Other: ……..

29. The last time you bought mercury, where did you buy it? (area and shop name/kind)
    1. ……
    2. Never bought it

30. Have you ever been informed about the risks of using mercury? If so by who?
    1. No, never been informed
    2. Yes, by WWF
    3. Yes, by colleagues/friends
    4. Yes, but I do not remember name of the organization
    5. Yes, by the media (TV, newspaper, radio)
    6. Yes, by: ……
    7. Other: ……..

31. How do you believe that people may get mercury in their bodies?
    1. By eating contaminated fish
    2. Skin contact with mercury
    3. Inhalation of fumes
    4. Don't know
    5. Other: ……..

32. One way by which people may get mercury in their body is by eating contaminated fish. Do you know what types of fish usually have the highest levels of mercury?
    1. Piscivores/fish eating other fish
    2. Large fish
    4. Don't know
    3. These types:……..

33. What do you think may be the effects of getting too much mercury in your body?
    1. ……
    2. Don't know

34. When someone has too much mercury in his body, what can he do to get well or get rid of it?
    1. You cannot do anything but wait, it has a long retention time
    2. Just wait a little, it leaves the body fast (<1 month)
    3. Have a blood transfusion/replace your blood
    4. Go to the doctor for medication
    5. Go to a traditional healer
    6. Stop working in gold mining
    7. Other: …… 8. Don't know

35. Do you think that the health of children that grow up in an area where gold mining takes place is affected by the use of mercury in this area?
    0. No, GO TO 37 1. Yes

36. How do you believe the health of children may be affected?
    1. They may get ill
    2. They may suffer from specific symptom, such as: ……
    3. Other: ……..

37. Do you believe that it is possible to mine for gold without using mercury?
    0. No, GO TO 36 1. Yes

38. If YES, how can one work without mercury?
    1. Using special machines, namely: ……..
    2. Wash the gold concentrate with a bate and only water
    3. Other: ……..

GO TO 40

39. If No, why not?
    1. Gold will be lost with the tailings
    2. Gold is too fine, it is impossible to capture it without mercury
    3. Don't know
    4. Other: ……

40. Have you ever heard about a device for burning of the mercury, named 'retort' (*retorta* (?)) ?
    0. No 1. Yes

41. Have you ever used a retort to burn gold? And if so, are you using a retort at present?
    1. No, never 2. Yes before, but not at the moment 3. Yes, still use it

42. If you used a retort before or if you are using one now, what has been your experience?
    1. It works great; I am very happy with it
    2. I don't like it because: ……
    3. Other: …….

43. If you never used a retort, or if you are not using one at the moment, why not? CIRCLE ALL THAT APPLY
    1. I did not know about it/did not know they existed
    2. It takes too much time burning gold using a retort
    3. I do not trust these devices
    4. We don't have such a device at the camp
    5. The quantities of gold I find are very small
    6. I just never bought one
    7. I don't know
    8. Other: ……

44. What do you think would happen if the government would ban the use of mercury in SSGM altogether by January 2015?
    ……
    ……

45. What would you like to learn about mercury in general, or mercury in small-scale gold mining specifically?
    ……
    ……
    ……

Thank you for you participation!