Report on the Impact of Mining on Health In Guyana

Joint Study

Between the

Guyana Environmental Capacity Development Project

Of the

Guyana Geology and Mines Commission

And the

Ministry of Health (Guyana)

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Executive Summary

During the period May-August, 2002, (GENCAPD), and (GGMC) collaborated with the Ministry of Health to conduct a survey to determine the impact of mining on health in mining communities. Anecdotal information suggested that mining was having an adverse effect, but actual evidence was needed so that interventions could be put in place to improve health and wellness in these communities.

Eyelash, and Arakaka, Region 1, in the Barima River, Kurupung and Isseneru, Region 7, in the Middle Mazaruni River, Mahdia, and Tumatumari, Region 8, Potaro River were the communities studied. The aims of the study were to assess the incidence of selected diseases and conditions namely, malaria, typhoid, mercury (Hg) poisoning, and dengue; to identify the existing behavioural practices, environmental and social conditions that contribute to these diseases; and to determine the effects of mining, on the behavioural practices, social, and environmental conditions.

A general questionnaire was administered to the residents whose mean average age was 33.6 years. A consent form was applied since blood and hair samples were taken from respondents. Also, microbiological and chemical analyses of the water quality were assessed.

Summary of Findings

1. All six communities studied had poor environmental factors as the common health problems include dengue fever, typhoid-like diseases, and malaria. Also residents dumped garbage and refuse indiscriminately; pit latrines were either poorly designed or non-existent, and the water tests, confirmed high faecal coliform count and e. coli making it unfit for drinking and domestic purposes.
2. All communities recalled mass smearing was done while over 50% of persons reported use of mosquito nets but Eyelash recorded lower percentages.
3. Most of the communities confirmed the use of Hg in the mining industry. However, Gunns strip and Isseneru, residents appeared to have a high level of hair Hg content but this might be attributable to the consistent fish-based diet rather than occupational hazards.

Recommendations

1. Conduct a National Consultation with the key stakeholders to develop the interventions to reduce the environmental conditions that impact on health and well-being in communities.
2. GGMC develop clear guidelines for all levels of mining and to maintain quality control.
3. A multi-sectoral approach should be the key strategy to address those factors, which have health implications and to monitor activities of miners in mining communities.

Conclusion

Community members and miners have demonstrated unacceptable social and behavioural practices, which impact on environmental health conditions negatively. Therefore, it becomes a necessity to raise public awareness and greater understanding of those factors that affect health and well-being and work collectively to reduce health risks.

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BACKGROUND

Historically, there are many health problems associated with mining, some as a direct result of the mining activities in relation to chemicals polluting the water, unfilled pits of water that lead to breeding of mosquitoes, etc., while others are related to the social circumstances surrounding mining, such as temporary accommodation without adequate sanitary facilities, and transient sexual relationships.

It has long been recognized that physical, social, economic, and environmental factors are the most significant contributors to health. Such factors as poor living conditions, poor sanitation and hygiene contribute to the spread of diseases, such as typhoid, tuberculosis and diarrhoeal diseases. On the other hand, improved water supply, housing and working conditions have led to significant improvements in overall population health. Thus, it is not the individual medical services, which might lead to overall health improvement. While crime and other negative social behaviour are not limited to any social strata of society it is certainly true that bad habits perceived to indicate wealth are more likely to be adopted by the lower socio-economic strata. As an example, smoking is currently more prevalent among lower socio-economic groups than in more affluent persons.

In Guyana, gold mining takes place in the interior of the country. Mining communities are characterized by rapid population growth, due primarily to the influx of miners and persons who provide services to them, as well as the lack of basic sanitary and waste disposal facilities. These conditions create the ideal setting for the emergence of vector borne diseases and diarrhoeal diseases. Surveillance reports from the Vector Control Service have shown that there has been a re-emergence of malaria in mining communities. There also seems to be the emergence of other febrile illnesses including dengue fever, and water borne diseases, such as typhoid fever, and other diarrhoeal disease.

Dengue fever is caused by 4 serotypes of dengue viruses and transmitted by the *Aedes aegypti* mosquito (Rozendaal, 1997). Dengue is an acute febrile disease that starts suddenly and lasts for a week or more causing headache, pain in joints, muscles and rash. This mosquito is highly domesticated and breeds in and around dwellings, in man-made containers, such as

water receptacles, flower vases, plastic containers, and old discarded tires (Gubler, 1998). The vector *(Aedes Aegypti)* could be reduced if breeding sites are eliminated. Dengue infections tend to emerge therefore in communities where there are abundant breeding sites for the *Aedes aegypti* mosquito, such as mining communities. Personal protection measures should include taking action to prevent daytime-biting mosquitoes, and the use of protective clothing, repellents, and house screening to reduce the vector in households (Rozendaal, 1997). The diagnosis of dengue is by the detection of antibodies to the dengue virus (Gubler, 1998).

Typhoid fever is a severe infectious disease caused by *Salmonella typhi.* The main route of transmission of this organism is the faecal-oral route and factors, such as poor personal hygiene, ingestion of fruits and vegetables that were not properly washed, and drinking water contaminated with faecal matter have been associated with typhoid fever (House *et al.*, 2000). Typhoid fever is diagnosed in persons who have coherent clinical symptoms together with the detection of the bacteria in the blood, stool or urine. The Widal test, based on the detection of O and H-agglutinins is used as an auxiliary method of diagnosis (Parry *et al.*, 1999). An increase in the Widal titres in acute (at the beginning of illness) and convalescent samples (taken during recovery) is often taken as being diagnostic of current typhoid fever. However, a single Widal test with O and H-agglutinin titres of 1:320 or more in a patient with clinical manifestations of typhoid fever, and in the absence of another cause of fever is often considered as indicative of typhoid fever (Parry *et al.*, 1999). A low Widal titre has been shown to be of poor sensitivity and specificity for typhoid.

Malaria is another major health problem reported in the selected communities. The Community Health Workers (CHWs) and/or the Medex revealed that community members are affected by malaria. The most common types of malaria recorded in these communities include *Plasmodium falciparum*, *Plasmodium vivax* and mixed infections (a combination of both *P. falciparum and P. vivax*), which occurs during the rainy and dry seasons. In Guyana, malaria is one of the most highly endemic public health problems, which results in severe illness and death especially in hinterland areas and/or mining communities. Malaria parasites enter the human body through the bite of a malaria-carrying mosquito *Anopheles.* The parasites invade the liver through the bloodstream and multiply (Rozendaal, 1997). However, malaria can be prevented if precautions are taken to avoid being bitten by the *Anopheles*

mosquitoes. Preventive measures include wearing protective clothing (such as during periods when mosquitoes seek their blood meals), applying insect repellent on exposed skin, using mosquito coils and other insecticide vaporizers, sleeping under mosquito nets and improving structures of dwellings to prevent mosquitoes from entering the premises.

Mosquitoes breed in quiet places close to the banks of rivers and creeks where there is protection from obstacles, protruding roots and other things (Rozendaal, 1997). In mining communities, the rivers, creeks, and ponds are the main source of water for bathing/washing, which takes place early morning and at dusk, these are most likely the periods when transmission of malaria occurs. Other risky practices in mining areas are wearing minimal clothing and exposing large amounts of body mass/flesh, which makes it easy for the mosquitoes to get their blood meal.

Mercury (Hg) is used extensively in the extraction of gold in gold mines in the interior of Guyana via a process of mercury amalgamation. Hg used in gold mining is discharged into the environment and finds its way into the aquatic environment. Inorganic Hg in the aquatic environmental mercury enters the food chain as a consequence of biotransformation into methyl-mercury, which bio-concentrates in carnivorous species of fish. Persons living in gold mining communities are therefore either exposed through gold mining or via the consumption of foods that have high mercury content. Prolonged exposure to Hg either through occupation or diet leads to elevated Hg levels in blood and hair. The hair Hg content has been shown to exceed blood Hg levels by a factor of 300 and has been widely used a biological marker for methyl-mercury levels in man (Barbos *et al.*, 1998). Mercury is both neurotoxic and nephrotoxic and elevated blood Hg levels are associated with neurological and kidney damage.

METHODS

The Guyana Environmental Capacity Development Project (GENCAPD), and the Guyana Geology and Mines Commission (GGMC), commissioned this survey with the aim of informing mine owners of the impact of mining on the health and environment in specific areas in Guyana, to equip them to make decisions and to introduce the interventions into their program of work.

Mining communities in Regions 1, 7, and 8 of Guyana, were selected because of concentrated mining activities currently being undertaken. The specific locations studied are Eyelash and Arakaka, Barima/Waini, Region 1, Kurupung and Isseneru, in the Middle Mazaruni, area of Region 7, and Mahdia and its environs in the Potaro section of Region 8. These communities, with the exception of Eyelash, are permanent settlements, with the residents to a large extent being Amerindians, but include Afro-Guyanese and Indo-Guyanese who have moved to these areas over 20 years ago and have assimilated into the culture of the indigenous people.

In addition three non-mining Amerindian communities in Regions 7 (Paruima village), Region 8 (Micobie village) and Region 9 (Gunns Strip) were selected and hair samples were taken from the residents for comparative purposes.

STUDY OBJECTIVES

There are many factors in these mining supported communities that either exist in the environment that are created or exacerbated as a result of mining. Thus, this study aims to identify these factors using the following objectives:

1. To assess the incidence of selected diseases and conditions namely, malaria, typhoid, mercury (Hg) poisoning, and dengue.
2. To identify the existing behavioural practices, environmental and social conditions that contribute to these diseases.
3. To determine the effects of mining, on the behavioural practices, social, and environmental conditions.

DATA COLLECTION

The survey utilized a questionnaire, the collection of samples including blood and hair, as well as water from the rivers, and other sources used by the community and observations.

The team collected quantitative and qualitative data from May to August 2002. With the assistance of the GGMC, the communities were sensitized. The physician and health educators worked mainly from the health facility or from temporary accommodations where facilities didn't't exist.

All persons who visited the health centre during the data collection period with either current or recent fever were invited to participate to the study. All persons who agreed to participate in the study were asked to sign a consent form (Appendix II) for blood samples to be taken. The respondents' read the consent form, and where necessary the interviewer explained the form to the respondents' before blood smears were taken. Two venous samples were taken under sterile conditions from each participant. One sample, a non-clotting specimen for blood culture for Widal testing and dengue antibody determination. Samples were stored at 4^{0} C until transported to the laboratory. Dengue testing was done using Pan Bio's Rapid Immuno-chromatography test. Diagnosis of typhoid fever was facilitated by the Widal test and confirmed by the isolation of *Salmonella typhi* in blood cultures. The hair samples for exposure to mercury poisoning were taken using guidelines provided by a GENCAPD liaison laboratory in Canada where the samples were sent for testing.

Water samples were collected and sent to the Food and Drug Department for bacteriological and chemical analyses. The environmental health specialist walked around the community to observe the environmental conditions and associated behavioural practices and collected water samples.

CONSTRAINTS

Due to heavy rainfall and flooding it was difficult and often impossible to travel to some of the survey sites, particularly in Region 1. During the visit to Region 1, the road from Matthew's Ridge to one of the larger mining areas, Eyelash was impassable. It took two days for the team to travel to Eyelash because the drivers and porters of the hired vehicle had to repair and patch several "bad spots" on the access road from Matthew's Ridge to Eyelash. This journey normally takes about 45 minutes. Initially, Arakaka was identified to be a major part of the study but due to many factors, such as poor roads, lack of accommodation and movement of many miners from Arakaka to Eyelash, which is a newly established mining settlement and at the time had a larger population, this community was included in the study. Thus, at Arakaka, data was only collected through the questionnaires, which was administered by the resident community health worker.

At Kurupung in Region 7, it was also the rainy season and the creeks were overflowing. As a result, it was not possible to travel to the mining camps with the usual mode of transportation – All-Terrain Motor Vehicles. The alternative means of accessing the camps was via Kurupung Creek using a boat and engine, which was unavailable at the time. A second visit was made to the area to collect data at Isseneru. This is a predominantly Amerindian community located approximately 90 minutes by outboard motor boat from Kurupung. Here, only a small number of respondents gave consent for hair samples to be taken because the residents were aware that there was no treatment available if mercury (Hg) content was above a certain level, and according to them, it was a waste of time to take the test since nothing could be done in terms of treatment.

It was virtually impossible to collect data on malaria from the six selected communities in the study. The Vector Control Program is a vertical program in the health sector and not integrated into the regional health services/facilities in each of the sites. As a result, no data was available and accessible to the researchers.

FINDINGS AND ANALYSES

During the period May 2002 through August 2002, 246 persons were interviewed in mining areas in 3 administrative regions of Guyana, namely Region 1, Barima/Waini: Eyelash and Arakaka; Region 7- Mazaruni/Cuyuni: Kurupung and Isseneru; and Region 8-Potaro/Siparuni: Mahdia, and Tumatumari. In addition 49 residents of the three non-mining communities (Paruima, Micobie and Gunns Strip) were interviewed and hair samples were taken between January-June 2003.

Sixty percent (60%) of the samples were either Amerindian or persons of mixed descent and in all of the communities, except for Eyelash, there were over 90% Guyanese. In Eyelash, 40.9% of the population are Brazilians. This is probably due to the fact that Eyelash is a new mining locality with high yields and the usual restrictions and legal framework have not yet been put in place, so people are not yet subject to the usual immigration and legal restrictions.

The population in these areas are predominantly male between the ages of 18 and 44, except in Isseneru where there are twice as many females (66.7%) as males (33.3%). On average, in

each community over 50% of persons in the study were either married or in common law relationships. Again, in Isseneru, 66.7% of the community were either married or living in common law relationships. The differences noted above in Isseneru, most likely stems from the fact that Isseneru being the only traditional Amerindian village in the study exhibits cultural patterns that are characteristic to traditional Amerindian villages. Of the respondents, 51.6% had only a primary education, while 42.3% had a secondary education or higher. The principal occupation of the head of the household in most communities was mining 48.8%, and 15% were involved in a variety of business ventures. However, in Isseneru, only 33.3% of the heads of household were involved in mining, while farming was the principal occupation of all the other heads of household.

The summary of the demographic characteristics of the persons interviewed, are shown in Table 1.

Table 1: Socio-demographic data on respondents

Variable	Categories	Number	%
Sex	Male	147	59.8
	Female	96	39.0
Education	Primary	127	51.6
	Secondary	89	36.2
	None	10	4.1
	Tertiary	9	3.7
	Postsecondary	2	2.4
	Community High	6	0.8
Race	Mixed	84	34.1
	Afro-Guyanese	73	29.7
	Amerindian	65	26.4
	Indo-Guyanese	18	7.3
	Portuguese	5	2.0
	White	1	0.4
Nationality	Guyanese	226	91.9
	Brazilian	12	4.9
	St Lucian	6	2.4
	Colombian	2	0.8
Marital status	Single	83	33.7
	Common-law	82	33.3
	Married	61	24.8
	Separated	9	3.7
	Divorced	6	2.4
	Widowed	4	1.6
Occupation of household's head	Mining	120	48.8
	Business person	37	15.0
	Other	21	8.5
	Government worker	16	6.5
	Farming	16	6.5
	House wife	13	5.3

In all communities, the survey revealed that the conditions and facilities existing influenced the health practices of the residents. In addition, there are also behavioural differences depending on the person's dwelling e.g. house/hut as against camp. According to the responses, many of the residents seem to rely on rain as their principal source of potable water (76.8%), however, this is questionable for two main reasons, water collection systems are difficult without gutters and from a tarpaulin serving as a roof, and secondly, the amount of

rainfall during certain periods of the year cannot fulfil all the basic needs of even a small household. Thus, it is likely that residents use rain water as well as water from other sources, similar to the 14.8% of the respondents who indicated that they obtained water from natural reservoirs such as rivers, creeks, or springs. Interestingly only 33.3% of respondents treated water prior to use, and chlorination was the preferred method of treatment.

77.2% primarily disposed of excreta by way of pit latrines. As recorded in the descriptions of the communities, it was stated that the conditions of many of the pit latrines in communities such as Eyelash and Kurupung were poorly designed and far below the standard specifications, and consequently seem to be geared for privacy rather than for the protection of the public's health. The high total coliform count, which is greater than or equal to ≥1600 (mpn/100mls), of the water samples suggest that even though residents may use pit latrines, faecal matter is found in the water sources. Respondents indicated that the preferred method for disposing of solid waste was by burning (38.2%), but 32.5% confessed to dumping garbage, which seems more likely since again, the physical environment of many communities provide the evidence that garbage has been dumped by the majority of community members.

Table 2 provides a summary of health practices demonstrated by respondents that are likely to have impacted on the situation in mining communities.

Table 2: Health Practices related to the Environment

Variable	Categories	Number	%
Water source	Rain water	189	76.8
	Other (river, creek & spring)	36	14.8
	Rain and other	21	8.4
Water treatment o	No	159	64.6
	Yes	82	33.3
Method of treating water	Chlorination	61	
	Boiling	14	
Excreta disposal	Latrine	190	77.0
	Other	51	21.0
	None	5	2.0
Solid waste disposal	Burning	94	38.2
	Dumping	80	32.5
	Burying	39	15.9
	Mixed	16	6.5
	Other	6	2.4

Over the last fifteen years, malaria has re-emerged in mining areas. Whenever there is a 'shout', the incidence of malaria increases significantly, so much so that many miners incorrectly believe that it is the mere existence of the mosquito that leads to malaria. One fact has escaped many miners, as well as other persons residing and visiting the area, is that people transport the malaria parasite from area-to-area. It is then transmitted within the area by the vector (mosquito) whose natural habitat is where mining takes place. This suggests that malaria is a health problem that is exacerbated by people involved in mining, both directly and indirectly. With this in mind, the survey sought to assess the behavioural practices related to malaria. Table 3 illustrates that the use of mosquito nets was over 80% in communities, such as Arakaka and Isseneru, it must be noted that these communities were not necessarily established as a result of mining, and most of the population have lived for more than 11 years. Of course, the use of mosquito nets alone does not necessarily prevent malaria, but research has shown that it reduces the possibility of being infected. Behavioural practices such as not covering most of the body (i.e. wearing skimpy clothing), bathing in the creek or river during swarming periods etc have been observed in the communities studied.

Table 3: Use of mosquito nets and period of residence by community

Community	% living in the community over 11 years	% living in the community less than 1 year	% using mosquito nets
Isseneru	55.6%	0%	88.9%
Arakaka	48.6%	31.4%	82.9%
Tumatumari	43.5%	21.7%	43.5%
Kurupung	36.8%	37.9%	54.0%
Mahdia	17.6%	42.6%	55.7%
Eyelash	0%	95.5%	9.1%

In addition, public health actions to prevent malaria include fogging, house spraying and mass smearing. The responses reveal that spraying of households is not done on a regular basis, but fogging seems to be more frequent in "mining camps", where there is no permanent presence of health workers, which leads one to believe that this operation is done by private persons rather than the Ministry of Health. In all communities, more than 50% of respondents recall that mass smearing had taken place in recent times. Thus, it would appear that in these mining areas, the diagnosis and treatment of malaria is the focus with only little attention in the prevention of malaria. Table 4 provides details based on respondents recall of the recent occurrence of spraying, fogging and mass smearing.

Table 4: Summary of recent occurrence of prevention/diagnostic actions for malaria

Community	Recall of recent spraying	Recall of recent fogging	Recall of recent mass spraying
Isseneru	55.6%	0%	88.9%
Arakaka	48.6%	31.4%	82.9%
Kurupung	36.8%	37.9%	54.0%
Mahdia	17.6%	42.6%	55.7%
Tumatumari	0%	60.9%	73.9%
Eyelash	0%	95.5%	9.1%

Table 5 illustrates a summary of respondents' recall of prevention and diagnostic services provided by the Vector Control Services of the Ministry of Health in mining areas in relation to malaria.

Table 5: Summary of respondents recall in relation to malaria related services

Malaria related action	Responses
Personal protection	
Use of mosquito nets	135 (54.9%)
Nothing	64 (26.0%)
Mosquito nets	24 (9.8%)
Other	22 (9.0%)
House spraying	
Don't know	83 (35.3%)
Never	69 (29.4%)
Previous years	48 (20.4%)
Current year	35 (14.9%)
Malaria fogging	
No	123 (50.0%)
Yes	86 (35.0%)
Don't know	35 (14.3%)
Mass smearing	
Yes	156 (63.4%)
No	61 (24.8%)
Don't know	27 (11.0%)

Mercury

The survey sought to assess the level of knowledge in the study communities about the various types of mining which are related to the level of mercury use.

Land mining was the main type of mining and 67.5% of participants indicated that mercury was used in the mining process. Table 6 shows the summary of information of mining activities and mercury use provided by respondents. 74% of all respondents said that someone in the household was involved in mining.

Table 6: Type of mining, use of mercury and source of protein

Community	Type of mining %			Mercury Use %		Major source of Protein %		
	Land	River	Mixed	Yes	No	Chicken	Fish	Other
Tumatumari	4.3	60.9	34.8	56.5	4.3	39.1	34.8	26.8
Arakaka	-	97.1	-	82.9	5.7	51.4	22.9	22.9
Eyelash	95.5	-	-	68.2	9.1	36.4	4.5	45.5
Isseneru	100	-	-	-	-	-	100	-
Kurupung	85.1	2.3	-	54	34.5	34.5	42.5	12.6
Mahdia	91.4	1.4	-	88.6	1.4	51.4	28.6	14.3

Clinical Results

Results were obtained for 77 dengue samples, 78 Widal samples and 70 blood cultures. Samples for which no results were obtained had either been haemolysed or mislabelled.

Dengue

Of the 77 dengue tests done, 6 were positive. All 6 of these patients demonstrated IgM anti-dengue antibodies indicative of current dengue virus infections. Based on the clinical manifestations, all patients had dengue fever (DF) as described by the World Health Organisation (WHO) Guidelines for diagnosis of dengue virus infections. Patients with DF were likely to be febrile, with headache, joint pain and muscle pain. Nausea, vomiting and diarrhoea were infrequent symptoms among these patients. The clinical manifestations of persons with DF were compared to those who had other febrile illnesses (Table 7). There was no significant difference between the symptoms of DF and those of other febrile illnesses. This suggests that diagnosing febrile illnesses based on clinical manifestations only, in the absence of confirmatory laboratory testing could lead to significant misdiagnosis and treatment.

Table 7: Clinical symptoms of persons with Dengue fever and other febrile illnesses

Symptoms	Frequency in DF (%)	Frequency in dengue negative patients (%)
Fever	83.3	79.2
Headache	83.3	73.6
Muscle Pain	83.3	55.6
Joint Pain	83.3	63.9
Nausea	66.7	43.1
Vomiting	16.7	12.5
Diarrhoea	0	22.5

Three of the DF cases were from Kurupung and 1 each from Mahdia, and Eyelash.

Tumatumari

The distribution of dengue seroprevalence by different socio-demographic factors is shown in Table 8. Dengue fever was more prevalent in females than males and in Amerindians than in any other ethnic group. Most DF patients lived in houses (prevalence 12.5%) rather than in other types of dwelling (prevalence 4.7%), lending to the possibility that the transmission of dengue is taking place in a domestic environment rather than in camps under field conditions. Research has shown that the *Aedes aegypti* mosquito that transmits dengue is a highly domesticated species and tends to breed and feed in and around dwellings, in man-made reservoirs, such as water storage containers, old tires, and plastic containers disposed around dwellings. In dwellings where dengue cases occurred, most persons indicated that either no one in the household was involved in mining or that the head of the household was employed in non-mining related activity. This seems to support the likelihood that dengue transmission is occurring in the domestic environment, far removed from mining activity. Dengue fever was more frequent in persons who did not use malaria prevention measures, such as bed nets, mosquito repellents (prevalence 9.4%), and spraying of dwellings than in those who did (prevalence 6.5%), even though the difference in prevalence was not statistically significant. The use of malaria preventative measures also seems to be protective against the *Aedes aegypti* mosquito that transmits dengue.

Table 8: Socio-demographic factors of persons diagnosed with Dengue Fever

Characteristics	Number of patients	Number of positive	Prevalence (%)
Gender			
Male	49	1	2.0
Female	29	5	17.2
Ethnicity			
Amerindian	24	0	16.7
Mixed	23	0	8.7
Afro-Guyanese	18	0	0
Indo-Guyanese	8	2	0
Portuguese	5	4	0
Types of Dwelling			
Other types (camps, huts etc.)	46	2	4.7
House	32	4	2.5
Occupation of head of household			
Mining	43	2	4.7
Non-mining	45	4	11.4
Household with miners	62	3	4.8
Household without miners	16	3	18.8
Anti-malarial protection	46	3	6.5
No anti-malarial protection	32	3	9.4
Excreta disposal			
Other	13	0	0
Pit Latrine	65	6	9.3

Water-borne diseases

Blood samples were taken from 70 persons to determine the presence of bacteria. Circulating bacteria was detected in 11 of these persons, 7 of them had *Klebsiella pneumonia* and 4 *Staphylococcus aureus*. The presence of these microorganisms, indicates transmission by either the faecal-oral route, the respiratory tract or via wound infections. Most of the persons with positive cultures came from Eyelash and Tumatumari (Table 9).

Table 9: The Distribution of cultures by community

Community	# of Cultures done	# of positive cultures	*Klebsiella*	*Staphylococcus aureus*
Eyelash	18	6	3	3
Tumatumari	13	4	3	1
Mahdia	16	1	1	0
Kurupung	23	0	0	0

The socio-demographic characteristics of persons with positive cultures are shown in Table 10. Males especially of Portuguese, Amerindian and Mixed races were more affected. Persons who collected rain for drinking purposes were less likely to have a positive blood culture than those who used water from natural reservoirs such as rivers, creeks and streams. Treatment of drinking water however, did not seem to reduce the frequency of positive blood cultures, thus it is likely that the water was either not properly treated, or only some of the water used was treated. Persons who indicated that their source of protein was chicken and mixed sources, that is, chicken and other meats including fish, were less likely to have positive blood cultures than those who consumed fish only. Most persons with positive cultures also indicated that they used pit latrines for the disposal of body wastes.

Table 10: Socio-demographic data of persons with positive cultures

Characteristics	Number of cultures N=70	Number with positive cultures N=11	Prevalence (%)
Gender			
Male	46	9	19.6
Female	24	2	8.3
Ethnicity			
Amerindian	22	4	18.2
Mixed	22	2	18.2
Afro-Guyanese	14	0	7.1
Indo-Guyanese	7	2	0
Portuguese	5	2	40.0
Types of Dwelling			
Camps	38	6	15.8
House	25	4	16.0
Other	7	1	14.9
Household without miners	14	2	14.3
Household with miners	56	9	16.1
Source of drinking water			
Natural reservoirs	14	4	28.6
Rain	46	4	8.7
Mixed, other (rain and natural reservoirs)	7	3	42.9
Treatment of drinking water	18	3	16.7
No Treatment	49	8	16.3
Unknown	3	0	
Excreta disposal			
Pit Latrine	57	10	17.5
Other	13	1	7.7

[1]**Vegetarian diet**

The clinical manifestations of persons with positive blood cultures were that of a non-specific febrile illness, characterized by joint pain, fever, headache, muscle pain, and nausea (Table 11).

Table 11: Clinical manifestations of persons with positive cultures

Symptoms	Frequency in patients with positive cultures (%) n =17	Frequency in patients with negative cultures (%)
Joint Pain	81.8	67.8
Fever	72.7	89.8
Headache	72.2	84.7
Muscle Pain	63.6	62.7
Nausea	45.5	52.5
Diarrhoea	27.3	23.7
Vomiting	9.1	15.3

None of the persons with positive blood cultures had *Salmonella typhi (*or any other Salmonella species), the organism that causes typhoid fever. If disease diagnosis was based solely on a positive blood culture for *Salmonella* species then none of these persons had this disease. However, the results of the Widal test for typhoid fever showed that 17 persons had O or H-agglutinin titres of 1:160 or more, but only 4 persons had titres 1:320 or more. None of the persons with Widal O or H-agglutinin titres of at least 1:320 had positive blood cultures, while one person with a titre of 1:160 had *Klebsiella pneumonia* isolated from the blood. If therefore a single Widal titre O or H agglutinin titre of at least 1:320 were considered diagnostic for typhoid fever, then, the seroprevalence of this infection would have been 5.2%. On the other hand, if a Widal O or H antibody titre of 1:160 were diagnostic, then, 17 persons would have been considered as having *Salmonella* infections with a seroprevalence of 22.1%. Factors positively associated with Widal O or H titres greater than 1:320 included afro-Guyanese males, who claimed to have treated their drinking water using the chlorination method (Table 12).

Table 12: Socio-demographic data of persons with Widal O or H-agglutinin titre 1:320 or greater

Characteristics	Number tested	Number with Widal O or H>1:320	Prevalence (%)
Gender			
Male	49	3	6.1
Female	28	1	3.6
Ethnicity			
Afro-Guyanese	18	3	16.7
Indo-Guyanese	7	0	0
Portuguese	5	0	0
Mixed	23	1	5.2
Amerindian	24	0	0
Types of Dwelling			
Camps	39	1	2.6
House	31	3	9.7
Other	7	0	0
Source of drinking water			
Natural reservoirs			
Rain	14	0	0
Mixed, Other (rain and	52	3	5.8
natural reservoirs)	11	1	9.0
Treatment of drinking	23	2[1]	8.7
water			
No Treatment	51	2	3.9
Unknown	3	0	0
Excreta disposal			
Other	63	3	4.8
Pit Latrine	14	1	7.1

[1] **By Chlorination**

The clinical picture of patients with Widal O or H titres > 1:320 were non-specific and not different from other febrile illnesses (Table 13). Even when a Widal O or H titre of 1:160 was used as the cut off titre, the clinical manifestations of *Salmonella* infections would have been non-specific (Table 14). The presence of low Widal titres in persons in developing countries, especially in rural communities, is a common occurrence given the poor sanitary and unhygienic conditions in these areas.

Table 13: Clinical manifestations of persons with Widal Titre of 1:320 or more

Symptoms	Frequency in patients with Widal O or H titres> 1:320 (%) n = 4)	Frequency in patients with Widal O or H Titres< 1:320 (%) (n = 73)
Joint Pain	50	64.4
Fever	50	80.0
Headache	25	78.1
Muscle Pain	50	57.5
Nausea	50	46.6
Diarrhoea	25	21.9
Vomiting	0	13.7

Table 14: Clinical manifestations of persons with Widal O or H-agglutinin titre > 1:160

Symptoms	Frequency in patients with Widal O or H titres> 1:160 (%) n =16	Frequency in patients with Widal O or H Titres< 1:160 (%)
Joint Pain	47.1	46.7
Fever	76.5	80.0
Headache	64.7	78.3
Muscle Pain	47.1	60.0
Nausea	47.1	46.7
Diarrhoea	17.6	23.3
Vomiting	23.5	10.0

Hair mercury (Hg) content

A total of one hundred and eight persons (108) were interviewed from eight (8) mining and non mining communities in Regions 1, 7, 8 and 9 (Table 15).

The mean hair Hg content of these residents was 11.595 µg/g (standard deviation 10.01 µg/g). Mean hair Hg levels was significantly higher among residents of Gunns Strip (24.770 µg/g) than those from Paruima (2.158 µg/g), Tumatumari (8.749 µg/g), Mahdia (5.255 µg/g), Eyelash (6.444 µg/g) and Kurupung (6.385 µg/g). There was no significant difference between the mean hair Hg content however of villagers from Gunns Strip with those from Isseneru (18.229 µg/g) and Micobie (21.326 µg/g).

Hair Hg levels were significantly higher among Amerindian residents (14.141 μg/g) than among persons of other ethnicities (Afro-guyanese 4.304 μg/g, Indo-guyanese 11.190 μg/g, Mixed 5.569 μg/g).

Long term residents were more likely to have higher mean Hg levels than persons who have been in the community for less than 1 year (Table 15).

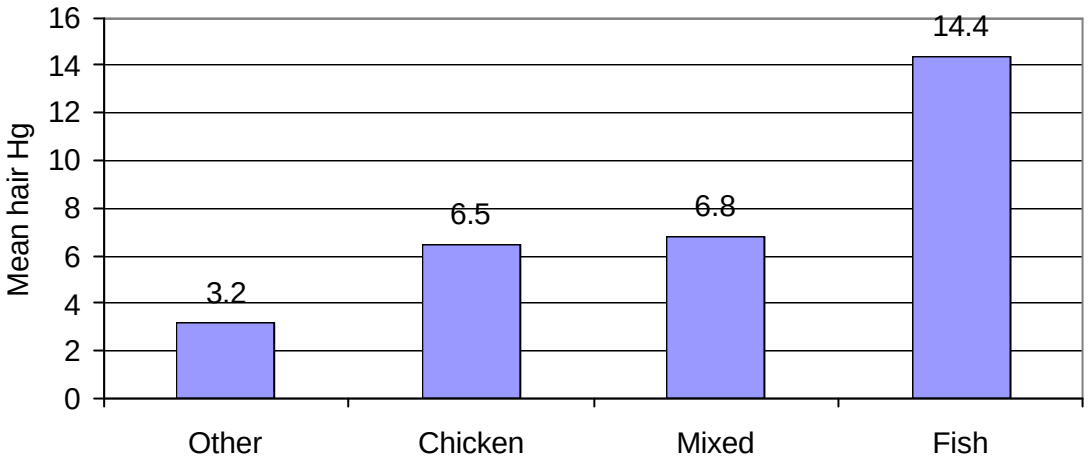
Persons with fish (14.436 μg/g) as a primary source of protein also has significantly higher levels of Hg than those who consumed non-fish protein (chicken 6.496 μg/g). There was however no difference between a primarily fish based diet and persons whose proteins was derived from different sources (6.832 μg/g), Fig 1.

Table 15: Socio-demographic characteristics of persons who had Hg samples tested

Characteristic	Number of Hg samples	Mean Hg level mg/g	p value
Community			
Eyelash	5	6.4	<0.05
Isseneru	8	18.2	ns
Mahdia	11	5.2	<0.05
Tumatumari	11	8.7	<0.05
Kurupung	19	6.4	<0.05
Paruima	18	2.1	<0.001
Micobie	15	21.3	ns
Gunns Strip[1]	16	24.8	-
Sex			
Male	63	12.4	ns
Female	45	11.0	-
Ethnic Group			
Afro-Guyanese[1]	12	4.3	-
Indo-Guyanese	4	11.9	0.05
Amerindian	75	14.1	0.01
Mixed	16	5.7	0.54
Time in community			
Less than 1year[1]	19	5.2	-
1-5 years	13	8.7	0.03
6 or more years	76	13.7	0.01

[1] **Group of comparison, ns = not significant.**

Figure 1 Influence of diet on mean hair Hg content



The clinical manifestations of chronic Hg exposure are shown in Table 16. Chronic Hg exposure was significantly associated with hearing loss and paresthesias. Persons with tremors, excess sweating, and insomnia also demonstrated elevated hair Hg levels, but this was significantly different from those who did not manifest these symptoms.

Table 16: The Correlation of clinical manifestations and mean Hg levels in hair samples

Symptoms	Number of persons	Mean Hg	Respondents p value
Paresthesia			
Yes	20	10.9	0.07
No	31	7.2	-
Memory Loss			
Yes	18	6.6	0.91
No	35	7.5	-
Insomnia			
Yes	25	9.8	0.64
No	28	7.3	-
Hearing Loss			
Yes	9	15.9	0.03
No	44	7.0	-
Excess sweating			
Yes	25	9.8	0.21
No	28	7.3	-
Tremors			
Yes	12	10.7	0.27
No	39	7.9	-

Water quality

Three water samples were taken at Kurupung; two from the Mazaruni River which is used by some residents for washing, bathing and drinking purposes and one from a rubberized tank at the health post. All were both microbiologically unsatisfactory as evidenced by high coliform counts and chemically unsatisfactory due to elevate pH, lead and total iron. At Mahdia two samples were taken from creeks used for domestic purposes. All were chemically unfit for human consumption as a result of high pH lead and total iron. The microbiological analysis was not done for Mahdia samples due to the samples deteriorating. Two samples were taken at Eyelash; both were microbiologically (presence of coliforms) and chemical unsafe for consumption (elevated pH, total dissolved solids, turbidity, lead and aluminium).

COMMUNITY PROFILES

Mining communities traditionally exhibit certain characteristics, thus, it is important to understand the context in which gold and diamond mining operations occur in Guyana. The background, physical and social characteristics from each study site are presented in three sections – the physical and social description, the information collected from the questionnaire and the results of the laboratory tests from the human samples and the water.

Eyelash

Eyelash is a recently established mining area, which is located in the Matarkai Sub-Region of Region 1, Barima/Waini; approximately 45 minutes drive with a 4-wheel drive vehicle from Matthews Ridge and about 40 miles from Port Kaituma, a river port accessible from Georgetown, Mabaruma, Moruca, and Charity by both large and small craft.

Eyelash has about 1,000 persons consisting of mainly Guyanese and Brazilian miners, the Guyanese hail from several communities that span the length and breadth of Guyana, such as Mabaruma, East Bank Essequibo, Essequibo Coast, Pomeroon, West Bank and West Coast of Demerara, Georgetown, East Coast and East Bank of Demerara, and West Berbice while the Brazilian community came from Boa Vista and Currera, many of whom are transient. Due to the fact that mining has only recently begun at Eyelash, the buildings are of a temporary nature made of wood and tarpaulin and are scattered haphazardly in the community.

Gold mining is the main economic activity. There are also other economic ventures to support the persons in the mining industry. These include grocery and clothing stores, restaurants, bars and discotheques with the usual commercial sex workers who provide their specific brand of services to satisfy the social and physical needs of the miners.

Eyelash is clearly not an established settlement, judging by the temporary appearance of the structures, which are wooden frames with tarpaulins serving as walls and roofs. The existing buildings serve a two-fold purpose as business premises and dwellings. These are located in clusters parallel to the long and winding road leading to the mining areas. The mining camps are located in what is described as the" back-dam" but within walking distance of the main road, the business places and the residential area. Behind the dwellings on the western side

of the road, there is a huge swamp and a creek, which is surrounded by scattered trees and cut tree trunks.

There are only a small number of poorly built pit latrines, and the general environment is littered with empty plastic bottles and tins, as well as garbage and refuse. These poor solid waste practices, and the thick vegetation in the vicinity of ponds filled with water, and swampy lands are breeding grounds for vector and water-borne diseases. These practices and conditions give the community an untidy appearance, which is usually associated with poverty despite the fact that the mining operations are very lucrative.

There is no piped water so people use water from the creeks, ponds, and water holes. However, there is electricity from the many hydro plants that exist in the community.

In Eyelash, there is a GGMC warden permanently stationed, supported by a mobile mines officer. The warden and the mobile mining officer provide technical guidance and direction in relation to mining and are also responsible for monitoring the environment. Health workers including vector control service personnel visit periodically to conduct clinics including taking blood smears, diagnosis, and treatment of all positive cases of malaria free of charge. In addition to the government employed malaria personnel, there are private persons providing microscopy services and treatment for malaria at a cost.
There is no school, police station, or church at Eyelash.

Questionnaire

At Eyelash, 22 persons were interviewed, data collected through the questionnaire and observation revealed that the population distribution by ethnicity, gender, and nationality was as follows: 13.6 Afro-Guyanese; 13.6% Amerindians; 45.5% Mixed and 22.7% Portuguese, with 81.8% males and 18.2% females and 59.1% of the population being Guyanese and 40.9% Brazilians.

The average age the people interviewed was 33.6 years (ranged from 20 - 51 years). 54.6% of these were either in married or common law relationships, while 40.9% of persons interviewed in this community were reportedly single. 68.2% reported that the head of the

household worked in mining while 13.6% were businesspersons. 18.2% were involved in other activities, such as farming, public sector or self-employed. In relation to the educational background of the head of household, 54.5% had only a primary education, while 40.9% had secondary education. Of the heads of households who were involved in mining, 40% had attended school beyond the primary level.

With Eyelash being a fairly new community, it was not surprising that according to all persons interviewed, there was no functioning community group and 95.5% of them had lived in the community less than one year.

The temporary nature of the community was also reflected by the fact that over 95% of the respondents lived in camps, 72% bathed in the creek, and 40% drank rain water (though there was not evidence of facilities for collecting rain water) and only 27% treated their water.

In response to questions about measures for protection against malaria, 77% said that they have no recollection of the camps being sprayed, 86% denied that fogging had ever been done but 63% indicated that mass smearing had been done. Over 70% did not sleep under mosquito nets. 90% of persons interviewed reported that they used pit latrines and 59% burned their garbage while 13% either burned or buried their solid waste, which is probably the reason for the unsightly appearance of the environment.

For the condition of the surroundings, 9.1% reported that there was a lot of bush, 40.9% said there was some other contaminant, whereas 5.5% classified their surroundings as being clean. The survey also sought to determine the effects of mercury use on plants, wildlife and river life such as fish on the health of persons in the area. According to the survey 95% of the mining done in Eyelash is land mining, but only 68.2% confirmed that they used mercury in their mining operations, some respondents, 9% actually denied using mercury in their operations.

Information on the source of protein was also important in relation to mercury use. In this community, 36% used chicken as the main source of protein, while 4.5% used fish (which

was more than likely not caught in the area), and 45.5% used other sources that include wild meat.

Clinical Results

18 blood samples were drawn from subjects at Eyelash and tested for dengue and typhoid fever (Widal test and blood culture). The laboratory investigations revealed that 1 person had DF, 6 persons had positive blood cultures (Table 10), and 1 had a Widal titre 1:160. None, however, had titres greater than 1:320. At Eyelash, the water sample was taken from a rubber tank in the vicinity of one of the miners' camp and the total coliform count was ≥1600 mpn/100mls, the faecal coliform count was 17 MPN/100mls while E. coli was recorded at 8. The water sources were highly contaminated and deemed inadequate and unfit for human consumption for domestic and drinking purposes. In fact, the coliform organism exceeded more than three times the acceptable amount in the bacteriological samples. The potable water should contain no faecal coliform organisms and not more than 3 coliform organisms per/100mls of sample (See Appendix III). Similarly, the chemical analysis yielded the same result.

Arakaka

Arakaka is a permanent settlement that was once an agricultural community. This village is located on the right bank of the Barima River in Region 1, along the road that runs between Matthew's Ridge and Port Kaituma. Access to Arakaka is either by air and road or by boat. There are airstrips at both Matthew's Ridge and Port Kaituma to which there are at leastthree flights a week. The return air ticket costs Twenty-two thousand dollars ($22,000) to either place, and the cost from any of the airstrips to Arakaka is about One thousand five hundred dollars ($1500) for a single trip.

There are 40 households with about 280 persons at Arakaka. Most of the population are permanent residents of this community, but some of the businesspersons have homes at both Arakaka and Georgetown. In addition, many miners have claims at Arakaka, but they often move around depending on where gold production may be higher. It is for this reason that many of the claim owners from Arakaka were at Eyelash during the data collection for this study.

Gold mining is the major economic activity in this community, however, there are several shops, which provide a wide array of goods and services, such as groceries, non-alcoholic and alcoholic beverages, buying and selling of gold. Some of the shops also provide recreational activities, namely shooting pools, and cable television through which the residents are able to keep in touch with the outside world.

The major form of mining done near the village of Arakaka is in the river, and along the road leading out of Arakaka near the Barima River, there are temporary structures that serve as accommodation and stores that sell clothing and serve as bars/discotheques where many commercial sex workers could be found. These businesses exist for the benefit of the miners and commercial sex workers.

Being a gazetted community, Arakaka has a nursery and an all-age primary school, two churches, a police station, a justice of the peace, a health centre, and a small guesthouse. Arakaka is also the official residence of the Chairman of the Neighbourhood Development Council (NDC).

The primary school has three teachers for the 100 + children within both the nursery and primary levels. The school has recently been renovated but many of the children in this community leave school early – the boys quit school to do mining and the girls to a lesser extent also participate in mining, become teenage mothers or work in the various shops and activities that support the mining industry, including becoming commercial sex workers.

The police station has four ranks with the corporal being in charge. The Chairperson of the NDC is also the justice of peace. His responsibilities include giving guidance in community development activities and assisting with the processing of certain legal matters.

Arakaka has a health centre, and the staff includes a Medex, a Community Health Worker, 2 malaria evaluators and 1 microscopist. These health workers provide maternal and child health care as well as curative care to persons who seek their services.

There is a 4-room guesthouse about 200 yards from the Police Station, which provides meals and accommodation for visitors. At Arakaka, some of the houses are built of wood with zinc roofs. Electricity is not available to everyone in the community but most businesses have small generators. Electricity is not generally shared with other members of the community.

Questionnaire

Questionnaires were administered to 35 residents. Of the persons interviewed 22.9% of the residents were Amerindians, 48.6% were mixed and 28.6% were Afro-Guyanese. 65.7% of those interviewed were male. The persons interviewed were in the 17 to 69-age range, with 54.3% having common-law relationships, 14.3% being married and 28.6% claiming to be single.

Only, 60% of the respondents who were head of household gave their occupation as mining, while 5.7% were farmers and 11.4% were businesspersons. 42.9% of household heads only had a primary education, while 31.4% had secondary education, 2.9% tertiary education and 17.1% had never attended school.

This is a well-established community, which is confirmed by the fact that 48.6% of persons interviewed had lived in the village over 11 years but only 20%of them were aware of the existence of a functioning community group, while 25.7% said there was no group and 51.4% did not know if there was a group.

Rainwater is used by 74.3% of the respondents and 5.7% used water from springs, but most of the respondents (65.7%) do not treat their water. Most (60%) of the bathing is done with river water, in the river or in the creek.

Due to the fact that Arakaka is an established community, most of the respondents live in houses, and the Amerindian population live in traditional huts. According to the responses, about 11% of the homes have water closets while 68% have pit latrines. Arakaka is a relatively clean community, but there are a small number of heaps of plastic drink bottles around the community, probably due to the fact that over 50% of respondents said that they dumped their garbage and 40% claimed that they burned their garbage.

The prevention of malaria seems to be a high priority in this community, because 82.9% of the respondents use mosquito nets as a protection against malaria, but in relation to public health interventions such as spraying, 65.7% could not recall the last time that houses were sprayed, while 31.4% of respondents agreed that fogging was done recently, and 71.4% indicated that mass smearing was done recently.

In relation to the use of mercury, 82.9% of the persons interviewed indicated that mercury was used in mining operations, but 5.7% said that as far as they were aware, mercury was not used in mining operations in the Arakaka area. At Arakaka, over half of the respondents (51.9%) used chicken as their main source of protein, 22.9% used fish and 22.9% used mixed sources of protein, that is, either fish, and wild meat or fish and chicken.
No clinical investigations or water samples were done in Arakaka due to circumstances beyond the control of the researchers.

Kurupung

Kurupung is a long established mining community in the Middle Mazaruni. It is about 100 nautical miles from Bartica. Access to Kurupung is either by air or river. A daily aircraft service is available at a cost of Twenty-five thousand dollars ($25,000) from Georgetown to Kurupung. The estimated flight time is approximately 65 minutes. In addition, Correia Mining Company and other small operators also provide jet boat service about three times per week from Georgetown to Kurupung. It takes approximately 14 hours by jet boat from Georgetown to Kurupung and the cost is approximately Eighteen thousand dollars ($18,000) round trip.

There are approximately 35 households at Kurupung with a permanent population of less than 230. However, whenever, there is a 'shout' the population increases significantly. Persons who live and work at Kurupung are mostly Guyanese of Amerindian, African, East Indian and mixed descent with a small number of Brazilians. Prior to June 2002, there was a large Brazilian population but there has been a decline in the diamond production and many dredges have moved from Kurupung to Eping and other areas in the Middle Mazaruni area where it was believed that more diamond existed.

Diamond is the main mineral found in this area, but there are small pockets of gold. There are also many grocery and clothing stores, eating-houses, and the usual bars and discotheques. There has been a general decline in the economic activity in Kurupung due to the fact that many of the transient miners have moved to other areas during the past year.

At Kurupung, there is a nursery and primary school, as well as several churches including a Pentecostal, Catholic and an Anglican church. There is also a GGMC outpost, a health centre and a police station.

The schools have approximately 60 children, between 3 - 14 years, but many of the children leave school by 13 years, seems to be typical in not only mining, but interior communities. However, where there is mining activity, the boys go into mining while the girls become involved in relationships that result either in pregnancy or become commercial sex workers, and in recent times some of the residents have become claim owners and miners.

GGMC has three officers based at the Kurupung outpost. The mines officers provide similar services to those conducted by their counterparts in other mining communities.

A medex and a malaria microscopist at Kurupung Health Centre provide basic maternal and child health care, outpatient, and vector control services to Kurupung as well as to residents of the nearby riverain areas and Isseneru. The medex refers cases requiring complex management and specialist care either to Bartica Hospital or Georgetown Hospital.

The police station has four ranks that are responsible for law and order at Kurupung, Isseneru and other neighbouring communities.

The councillor a permanent resident of Kurupung is the community representative on the Neighbourhood Democratic Council (NDC). The Kurupung Community Development Council was responsible for improving the community, and was comprised of the regional councillor and other influential persons in the community. This organization is not functioning at the present time; however, a youth program was formed under the President's Youth Initiative Program.

Most of the houses are built of wood with zinc roofs and in fair condition. There is the government compound where the police station, health centre and school are located. The living quarters in this section of the community have water closets with septic tanks and water storage facilities that are replenished through rainfall. The approach to the village at the mouth of the Kurupung Creek is littered with heaps of garbage and refuse- cardboard boxes, tins, and plastic bottles but Kurupung village itself is relatively free of garbage, and refuse. Most of the businesses places have generators and provide electricity to residents.

Questionnaire

87 residents were interviewed. Of these, 39.1% were Afro-Guyanese, 24.1% Amerindians, 31% of mixed ancestry, and 5.7% were Indo-Guyanese. Among the respondents, there were 62.1% males and 37.9% females ranging in age from 13 to 86 years. The majority (95.4%) of the population were Guyanese with a few St. Lucians and Brazilians. 41.4% of the persons interviewed lived in common-law relationships, 32.2% were single and 20.7% were married. 73.6%of the respondents indicated that someone in the household worked in mining. Of these 57.5% were heads of household. Among those interviewed, business persons accounted for about 20% of heads of household. At Kurupung 50% of the head of the households were miners who had an education level beyond the primary level. In addition, only 42.5% of household heads had primary education, while 50.6% had secondary education. Despite the fact that this is a well-established community, 37.9%of those interviewed had lived in the community for less than 1 year, 19.5% between 1-5 years; and only 36.8% had lived for 11 years and more. It is logical to conclude that most of those who had lived in the community for less than a year were still living in camps (24.1%) as indicated in the survey.

In relation to the existence of community groups, 50.6% of the respondents said there was a functioning community group; 19.5% did not know; and 29.9% indicated that as far as they were aware, there was no functioning community group.

Enquiry into hygienic practices revealed that 85% of the community drank rainwater, but most persons (51.7%) did not treat their water. Most people (60%) bathed either in the creek or river and over 82.8% used pit latrines

According to respondents over half (54%) of them slept under mosquito nets, but there was little activity by the Vector Control services, only 9% could say with any certainty that there had been spraying or fogging in recent times. DDT was the chemical used for residual spraying of internal wall and surfaces of buildings, while Malathion was used for fogging. However, mass smearing has been taking place periodically.

According to 85% of respondents, land mining is the most common form of mining, and although mining is not done in the immediate vicinity, mining activities still affect the rivers and creeks- 54% of those interviewed confirmed mercury use in mining operations in and around Kurupung. Unlike the other areas surveyed, fish (42.5%) is the most common form of protein consumed.

Clinical Results

At Kurupung 30 dengue samples were taken of which 3 were positive. 30 Widal samples were taken of which 11 were positive when a cut off of 1:160 was used. However, when the cut off point of 1:320 was used only 4 of the samples proved to be positive. 23 blood cultures were taken but none proved to be positive for microorganisms.

Water Samples

At Kurupung, the water samples were taken from four sources. Three of the four samples were analyzed while one source of water had insufficient water media, and was rejected by the laboratory. These include: Kurupung Creek: at two points; one within the vicinity of the Health Post; and the other in the river near CC Joseph's Grocery Store; another sample was taken at the Health Centre from the rubber tank connected to the gutters of the roofing.

Isseneru

Isseneru is located in the Middle Mazaruni River, Region 7 approximately 75 minutes by river with 150-horse power engine from Kurupung. It is an Amerindian village with a population of less than 200.

Many of the residents move around in search of employment – mining and farming. During the school holidays, children and parents live on their farms, which are usually not located in the village but along the river banks and quite a distance from Isseneru.

There are two main forms of economic activities carried out at Isseneru and nearby communities – subsistence farming, such as cassava, eddoes, plantains, peppers and fruits, namely banana, papaw, and citrus. There is also gold and diamond mining. In this community, there are only a few shops, which sell groceries including tinned foods and one shop also serves as a bar/discotheque.

At Isseneru, there is an all age school and children who are successful at the Secondary School Entrance Examination (SSEE) usually go to Bartica Secondary School as well as secondary schools in Georgetown. The school, which has four teachers, was recently rebuilt. It is a well-painted and adequately ventilated one-flat building with concrete walls and a zinc roof. Four well-constructed pit latrines also exist for the use of the school children.

The Isseneru Health Post is shared by two categories of health workers: the Community Health Worker (CHW), and vector control service workers whenever they visit. The CHW provides basic health care services and conducts health education and promotion activities. Review of the health records revealed that malaria, diarrhoeal diseases, and scabies are common health problems.

There is no police presence at Isseneru but the Kurupung Police Station is responsible for law and order at Isseneru.
Many of the residents of this village are members of the Seventh Day Adventist Church.

Electricity is limited to the premises of persons who own generators; consequently, not many of the residents have access to electricity.

Typical of Amerindian villages, the houses are scattered and are made of wood with troolie roofs and in some cases, zinc roofs. However, the head teacher's house is built on stilts, with concrete walls and a zinc roof. The teacher's house also has a water closet and septic tank.

Thick lush vegetation surrounds Isseneru village, which is also very clean. The methods of garbage and refuse disposal is either burying or burning. Rainwater is collected for drinking and cooking and persons wash and bathe in the river.

Questionnaire

Eight questionnaires were administered in Isseneru. This is an Amerindian village and not surprisingly 88.9% of the persons interviewed were Amerindian with 66.7% females and 33.3% males ranging in ages from 16 to 63 years. Over half (55.6%) of the persons interviewed were married and 11.1% were in common-law relationships. 55.6% lived in the community between 1-5 years and 44.4% for 11 years and more.

The occupation of the head of household of 66.7% of the persons interviewed was farming but 66.7% said that someone in the household was involved in mining. At Isseneru 66.7% of the head of the households who were miners had an education level beyond primary school while 77.8% of household heads among the respondents had only a primary education; 22.2% had secondary education. All of the persons interviewed indicated that there were no functioning groups in the community.

The survey revealed that 100% of the respondents used rainwater and did not treat their water for drinking. 55.5% bathed either in the river or creek, the others used rainwater from their tanks. There were a few rubberized tanks that provided water to persons; these were located at the health centre, school, and the homes of 2 residents - the head teacher, and a shopkeeper. In relation to protection against malaria, 88.9% of those interviewed slept under mosquito nets, but very little information was given about spraying, fogging or mass smearing. Similarly, for garbage and sewage disposal, only 11.1% of the respondents gave answers related to these practices. Based on observation in the community, the location was relatively free of litter, and there were a few pit latrines visible.

In this community, the major source of protein is fish, more than likely found in the river.

Clinical results

At Isseneru, 8 Widal samples were taken but the results have not been received from the laboratory. No other blood samples were obtained at this location. No water samples were taken in this community.

Mahdia

Mahdia is an established settlement rich in minerals, and located in the Potaro area of Region 8, Potaro/Siparuni. Mahdia is the administrative centre of Region 8.

Mahdia can be reached by air and road. The return airfare is thirty eight thousand dollars ($38,000). In early years, the Bartica/Potaro road was used to travel to Mahdia by four wheel drive vehicles and heavy-duty trucks. However, in the last 15 years, an all weather road has been constructed though travel by road is difficult during the rainy weather. Minibuses travel daily from Georgetown to Mahdia and the return fare is Nine thousand dollars ($9,000).

Mahdia has a permanent population of about 3,000 persons. The community is subdivided into Mahdia central and Campbelltown. Many of the residents of Mahdia are St Lucians who settled in the area several years ago while Campbelltown is an Amerindian settlement. More recently many Brazilians and Colombians have moved into the area to mine for gold.

Mining is the major economic activity, however, there are many businesses selling groceries, clothing, and vegetables. At Mahdia, there are a few hotels and a regional guesthouse, and all have accommodation for persons who require basic comfort when visiting Mahdia settlement. In addition, there is one gas station and several motor and electrical/mechanical shops, which service and repair motor vehicles and engines for miners. Organised prostitution through brothels (Caimoos) is a thriving business in Mahdia.

In central Mahdia within the government compound, houses are in good condition, also many of the other houses are well built and maintained, however, it is observed that persons, mostly transient miners, have taken up residence in some of the abandoned buildings and others have constructed temporary structures. At Mahdia, persons seem to dump garbage, and refuse indiscriminately and this is evident along the road to the airport leading out of Mahdia. The

environs of Mahdia are heavily forested and most of the mining camps are located in those areas. The ponds and creeks that run through the community have a creamy colour caused by the mining activities further up the river. On the outskirts of Mahdia there are several mining camps with temporary structures. It was observed that many of the camps had no pit latrines but that there were relatively free of flies, garbage and refuse.

There is a district hospital, which is staffed by a medex, staff nurse and other auxiliary staff, such as malaria personnel, environmental health assistant, and CHWs.

There is also a nursery and a primary school, but many of the children leave school at an early age, as has been observed in other hinterland communities. In the Government compound, there is the Mahdia Police Station, the regional administrative building, the Hospital complex, the office of the GGMC, the post office and a ball field with a pavilion for outdoor sporting activities.

In the areas surrounding Mahdia, there are several mining camps, interviews were conducted and samples were collected at Dickman Hill which is a mining area that is located approximately 6 miles from Mahdia by 4 wheel drive vehicle or truck. One of the mining camps in this area is owned by Columbians who have a medium size mining operations.

Questionnaire

The findings of the 70 questionnaires administered at Mahdia and nearby mining communities revealed that of the respondents 32.9 % were Afro-Guyanese, 15.7% were Amerindians and 38.6% were of mixed origin. This group of 51.4% males and 45.7% females consisted of 91.4% Guyanese, 4.3% were from St. Lucia, 2.9% were Colombian and 1.4% were Brazilian. The respondents ranged in ages 16 to 81 years of whom 30% were married, 35.7% were single and 24.3% were in common law relationships. The majority (42.6%) of those interviewed had lived in the community for 11 years or more, while 23.5% have been in residence between 1 to years and 17.6% lived in the community for less than 1 year.

Although only 37.1% of the heads of households worked in mining, they also reported that 74.3% of them had someone in their household working in mining, and the occupation of

14.3% of the heads of household were in business. 7.1% were involved in other activities, such as government employees; farmers and self-employed persons 57.1% of the heads of household of the respondents had only a primary education. At Mahdia 42.3% of the head of the households who were miners had an education level beyond the primary level while 30% had completed their secondary education.

Information was sought on the social aspects of the community and 45.7% of persons interviewed said there was a functioning community group, while 30% of them, said there was no group, and 24.3% did not know if there was a functioning community group.

In relation to practices that affect health, 85.7% of respondents drank rainwater, but only 31.4% treated the water. It would appear that because this is a regular village, most persons living in houses (68.6%) bathed at home (58.6%) while of 32.8% bathed either in the creek or in ponds. The survey revealed that 75.7% of persons interviewed used pit latrines and 20% had water closets. 15.7% dumped their garbage, 40% of them claimed to burn their garbage and 27.1 % buried their solid waste. 78.6% felt that the environment had too much bush.

55.7% of those interviewed slept under mosquito nets to protect themselves against malaria, and according to 72.9%, the area was fogged in recent times, and 84.3% agreed that mass smearing has been taking place. Most persons interviewed were unsure of the last time spraying was done in the community.

Land mining is the predominant process in this area, and according to 88.6% of persons interviewed; mercury was used in the process. Fish was the major source of protein for 28.6% of the persons interviewed and 14.3 % used mixed sources.

Clinical results

At Mahdia 15 dengue samples were taken of which 1 was positive. 16 Widal samples were taken of which 2 were positive when a cut off of 1:160 was used. However, when a cut off point of 1:320 was used none of the samples proved to be positive. 16 blood cultures were taken but only 1 proved to be positive for microorganisms.

Water samples

Water samples were collected from two sources: a reservoir at Proto Mahdia Mining Company, and the fresh water spring, which supplements the water supply for the Mahdia community, to conduct microbiological and chemical analyses. However, the microbiological analysis was rejected since the quality of the water sample did not meet the requirements of the Food Microbiological Sampling Requirements. The chemical analysis also showed that the water samples did not meet the requirements for pH, lead and total iron as specified by the WHO standard for drinking water.

Tumatumari

This community is situated along the riverbanks in the vicinity of Tumatumari Falls. Most of the mining is done in the river and these operations are owned and managed by Venezuelans, Brazilians and Guyanese. In addition, there are many itinerant miners and a few permanent residents in the specific communities.

Questionnaire

Tumatumari has a population of approximately 100 residents. 60.9% of the residents (23 persons interviewed) of Tumatumari were Amerindians; 17.4% East Indians; 13% Africans while 8.7% were of mixed race.

Of the persons interviewed, 56.5% of the population were males, 95.7% were Guyanese and 4.3% Brazilian, 34.8% were single, 26.1% married and 13% were in common-law relationships, being divorced and separated had minimal percentages.

Occupation of head of household, only 21.7% reported that the head of the household worked in mining, while 17.4% were housewives, 17.4% farmers, and 13% were businesspersons.

In terms of education of the head of household, 69.6% had only a primary education. 13% never attended school and 8.7% had secondary education. At Tumatumari only 20% of the head of the households who were miners had an education level beyond primary school while no one had a tertiary education.

In relation to functioning community groups, 56.5% said there was a functioning group, 17.4% said there was no group and 26.1% did not know.

Chicken was the major source of protein with 39.1% of the respondents, while 34.8% ate fish, and 26.1% consumed mixed sources.

The majority of respondents (45.3%) lived in the community for 11 years or more, 21.7% lived in the community for less than 1 year.

The source of drinking water for at least 47.8% of the respondents was rainwater while 21.7% drank water from the creek and the remainder accessed water from other sources. 78.3% did not treat drinking water. Of those who treated the water, 80% chlorinated and 20% boiled. 47.8% of the respondents said they used no measures while 43.5% said they used mosquito nets.

Source of water for the purpose of bathing/washing showed that 39.1% either bathe in the river or with river water, 34.8% bathe with creek water and others use ponds and other makeshift systems with water connections.

River mining was reported by 60.9%, mixed mining by 34.8% and 4.3% reported land mining. With respect to the use of mercury, 56.5% affirmed that this was used while 39.1% did not know for a fact whether mercury was used in mining while 4.3% denied mercury use.

For the disposal of excreta , 91.3% reported latrine use while 8.7% reported no method.

In regards to dwelling, 73.9% lived in houses, 8.7% lived in camps, 4.3% on pontoons and 13% lived in huts. Respondents provided information on their methods of solid waste disposal, which showed that 43.5% dumped, 30.4% burnt, and 17.4% buried their garbage and refuse.

For the condition of surroundings 34.8% reported bush, but no one classified their surroundings as clean. For the last time dwelling sprayed, 26.1% reported no knowledge of

when last spraying took place and 21.7% denied that any spraying took place. In terms of fogging 60.9% respondents affirmed there was fogging, 30.4% denied and 8.7% did not know if there was any fogging. The majority, 73.9%, affirmed that malaria mass smearing took place whereas 8.7% said they did not know.

Clinical Results

At Tumatumari 15 dengue samples were taken of which 1 was positive. 13 Widal samples were taken of which 5 were positive when a cut off of 1:160 was used. However, when a cut off point of 1:320 was used none of the samples proved to be positive. 13 blood cultures were taken and 4 proved to be positive for micro-organisms.
Water samples were not taken at Tumatumari.

DISCUSSION

Mining impacts on various aspects of physical and social environments of the community and can thus be expected to adversely affect population health. Our findings clearly indicate that this is the case in the communities studied. The housing and sanitary conditions were deficient and in all instances water supply was severely compromised. The social impact of mining is seen in the imbalance of males to females in all communities, in the relative poverty that persists in the face of wealth generated in mining activities and in the weakness of the family structure manifested by the high levels of unattached adults. The efforts to control malaria and other vector-borne diseases appear to be ineffective.

The six communities appear to have some common diseases and environmental conditions. For example, a review of the health records showed that malaria, diarrhoeal diseases and scabies are among the most common health problems. These health conditions and diseases are classified as vector and water borne diseases caused by mosquitoes, flies, and contaminated water used for various types of consumption and dirty environment.

The study identified that there are several behaviours as well as social and environmental factors associated with mining that affect the health of persons living in or within close proximity to mining communities. Among the major issues are gender imbalance, limited attention to personal prevention practices, unhygienic and unsanitary environmental

conditions, inadequate basic infrastructure, limited support services and legal mechanisms, and improper mining practices. In all mining communities, similar conditions existed that enhanced mosquito breeding, which could aid in the transmission of malaria. These conditions include stagnant pools, slow flowing streams, and large metal containers with aquatic vegetation, all breeding sites for mosquitoes.

Flies were evident in large quantities in many of the locales visited due to persons indiscriminately dumping refuse. In all cases, contamination of water supply sources whether stored (storm/rain) or fresh surface water (rivers/creeks/ponds) possibly occurred as a result of indiscriminate disposal of faeces (poor latrines facilities), which are washed into the natural water sources during the rainy season. In addition, droppings of birds and wild animals that frequent such localities also contaminate the water source. In the case of stored water supply, the contamination occurs through droppings of birds, and small animals, such as rats, and snakes.

Thru chemical analysis carried out on the water collected from some of the sources described above, it was observed that the level of chemical contamination was unacceptable for domestic purposes. Also, this situation was aggravated by the indiscriminate use of various chemicals used among miners in the production of gold. The chemicals are washed into the natural water sources, which show a creamy colour from the effluence, thus, contaminating the water sources. In addition, the indiscriminate disposal of rubbish (tins, bottles, old tires, old drums and reservoirs), also results in the breeding of *Aedes aegypti* mosquitoes, could lead to the transmission of dengue.

This suggests that in order to reduce the negative impact of mining on health, it is necessary to employ the health promotion strategies, which address those factors that impact on health and to regulate mining activities. Also, to provide services, which are culturally appropriate to mining, and to engage persons living and working in mining communities to develop a greater sense of pride in the environment, as a means of creating a place that is “miner friendly”, etc.

The mean hair Hg content in this study was 11.6 µg/g, but there was significant variation from community to community. The factors notably associated with increased hair Hg content however were residents of Isseneru, Micobie and Gunns Strip, who were of Amerindian race, including residency in the community for more than one year, as well as a diet, high in fish. Mercury exposure in mining communities is either through occupational exposure to elemental Hg or through dietary introduction of methyl mercury. Elemental mercury released into the environment is bio-transformed to methyl mercury which is known to bio-accumulate in fish. In previous studies, it was shown that the Hg levels in certain species of tropical carnivorous fish were higher than that in other types of fish. It was also recognized that these fish were also the preferred species for consumption by residents of interior communities. It is quite likely therefore that the high hair Hg content in persons who consume fish, observed in this study, was due to the consumption of carnivorous fish. The elevated hair Hg level found in Amerindians may similarly be due to the higher dietary intake of fish by this social group than by other ethnic groups. Likewise, at Isseneru, Micobie and Gunns the majority of residents were likely to be Amerindians, and also appeared to have high dietary intakes of fish. Interestingly Paruima, an Amerindian village, had the least hair Hg content. These residents because of their religious persuasion were likely to be vegetarians and low consumers of fish.

Long-term residents of mining communities demonstrated significantly higher hair Hg levels than persons who had been in the communities for less than a year. This observation might be due to chronic dietary exposure to Hg among long-term residents. Recent migrants to these mining communities were likely to be iterant miners from areas of Guyana where environmental Hg contamination was low. These persons were also less likely to consume fish as the primary source of protein than residents who had lived longer in the communities. In this study Hg levels were lower in persons who were from non-mining households than from households of miners. The majority of persons with elevated Hg levels were therefore exposed through diet rather than through occupation. The only clinical manifestations associated with elevated hair Hg were hearing loss and paresthesias. Persons with other symptoms such as insomnia, tremors and excess sweating also had higher hair Hg levels but these were not significantly different from persons who did not have the manifestations.

A summary of findings in relation to each community is presented in the subsequent paragraphs.

Eyelash

At Eyelash, the environmental conditions are very poor with lots of tall trees and poor garbage and refuse practices. Most of the dwellings were temporary structures which were poorly designed with a limited number of pit latrines. Garbage and refuse were dumped in an ad hoc manner creating breeding sites for flies and other vectors that could result in the spread of diseases, such as malaria, and dengue. In addition, only a small number of respondents recalled recent mass spraying and taking preventive measures to reduce malaria, and dengue fever. Also, the bacteriological and chemical analyses of water confirmed high faecal coliform count and E.coli, which makes it unsafe for human consumption, as it could contribute to diseases such as typhoid and other diarrhoeal diseases. In relation to mercury, many of the miners used Hg to amalgam the gold, Most of the respondents had mixed sources of protein, such as chicken, fish and kinds of meat. The consumption of fish was low and showed very little increase in Hg levels in respondents tested (6.4 µg/g).

Arakaka

Arakaka is a relatively clean community with lots of bushes, swamps, and pools of water in and around the community during and after the rainy season, which contributes to the spread of malaria. However, a significant number of respondents recalled mass smearing and reported the use of bed nets to prevent the spread of malaria. Most of the respondents revealed that Hg was used in mining and persons had mixed diets, that is, chicken was the main source of protein with fish and other kinds of meat eaten equally. Nevertheless, as mentioned no hair samples were taken in this community.

Kurupung

The creek/river banks at Kurupung are strewn with garbage and refuse, thus polluting the creek/river and resulting in the proliferation of flies and rodents. The village is surrounded by tall trees and bushes, which are natural habitats for mosquitoes, which could result in the

spread of malaria and dengue fever under the appropriate conditions. About half of the respondents recalled recent mass smearing being done in the community to ensure early identification and treatment for malaria. Although many persons have water collection facilities the bacteriological and chemical analyses confirmed that the quality of water was inadequate for domestic and drinking purposes. Respondents explained that Hg was used when gold was found but the main mineral accessed in the area was diamond and Hg not used in this process, however, the level of Hg was 6.4 µg/g. This may explain the low level of mercury found in this community. The sources of protein were mixed – a combination of chicken, other meat kind and many of the respondents ate fish.

Isseneru

This community is relatively clean but the presence of lush trees and other vegetation, natural habitats for the breeding of vectors, could contribute to the spread of malaria. Most of the respondents recalled mass smearing being done in the community. Mining was not carried out in this village; however, the most significant finding was the fact that Hg levels were very high among the respondents tested. Community members are mainly Amerindian who have a consistent diet of fish caught from the river where effluent from mining production flows into the nearby Mazaruni River and creeks. As a consequence, Hg is ingested and sustained at a high level in community members because of the daily food consumption pattern of a fish-based diet rather than from exposure to Hg within the workplace. The Hg levels were quite high (18.2 µg/g). Water quality was not tested.

Mahdia

In Mahdia, community members live in poor environmental conditions: garbage and refuse were dumped in an ad hoc manner and lush trees and vegetation facilitate the natural breeding grounds for vectors and flies. Almost half of the respondents recalled that mass smearing was done and used mosquito nets to stem the transmission of malaria and dengue fever. Most of the respondents revealed that Hg was used; the discolouration of creek and pond water show evidence of Hg use. The Hg level was low in this community, 5.2 µg/g. Water quality was not tested. The Government Analyst microbiological unit rejected the water sample because two of the criteria were not met: (a) The water sample must be taken within 24 hours and

submitted to the laboratory for testing within the same period; and (b) Water must be stored at a temperature of 2-5°C in order to be tested.

Tumatumari

At Tumatumari the environmental conditions were poor as was found in all the communities above. Many of the residents had a high prevalence of dengue fever and typhoid. Interestingly, the persons confirmed with dengue fever were not miners and the vector *(Aedes Aegypti)* live under domestic conditions. Also, three-quarters of the respondents recalled mass smearing, and less than half of the residents claimed to use mosquito nets, which could possibly lead to early identification and treatment for dengue fever. Also, water-borne diseases appeared to be a problem since three persons were diagnosed with *Klebsiella pneumonia* and one confirmed *Staphylococcus aureus,* which suggest that the water quality was poor, and water treatment was either insufficient or non- existent. About half of the respondents reported that Hg was used. Their diet consisted of mixed sources of protein, such as fish, chicken and other kinds of meat. Hg content in hair was 8.7 µg/g, higher than the WHO recommended standard of 7 or less µg/g. Water quality was unknown because of non-testing.

CONCLUSION

Mining is having a serious impact on the social and physical environment in the regions studied. This impact is greater in the newly established (Eyelash) communities when compared to the more established areas such as Kurupung and Mahdia. There is need for organization of the social and physical environment in relation to the establishment of dwellings, water treatment facilities and safe practices, garbage and human waste disposal. In addition, clear guidelines have to be established and enforced to reduce the clear and present danger, which impacts negatively on the health of community members and the mining community (miners) itself. Finally, an intersectoral approach would be most appropriate when developing the interventions for the problems affecting health and well-being. Perhaps, ideas and solutions to the problems might evolve when key stakeholders meet to discuss and understand the implications of these problems at the proposed National Consultation for the communities in this study.

RECOMMENDATIONS

To: GGMC

Clear requirements must be established for all levels of mining activities. These must include sanitation, solid waste disposal, water treatment and vector-borne disease prevention as a responsibility of the miner. The miners must be required to cooperate with Ministry of Health officials in the development of standards for the treatment of diseases arising within the mining communities. Enforcement authority must be invested in personnel for the policing of these standards. Maintenance of social and family structure must be a priority for miners and such facilities as conjugal visits must be afforded workers.

To: Ministry of Health

Establishment of guidelines to monitor the activities of miners and mining communities must cover areas, such as occupational safety and health, hygiene, sanitation, water protection and vector-borne disease control. Health personnel must be made available to mining communities at a cost to be borne by the miners. Health Education/Promotion activities must be ongoing as it cannot be assumed that the relevant information is available to the community.

General

A multi-sectoral approach must be taken to arrest the deterioration in health occasioned by mining. The Ministries of Health, Education, Culture, Youth and Sport, Social Services as well as non-governmental organizations (NGOs) must collaborate for the improvement of health in these communities. Church groups, teachers and health educators all have an integral role to play in this health improvement effort.

The *Anopheles darlingi/Anopheles braziliensis* mosquitoes help to transmit malaria while the *Aedes Aegypti* assist in the transmission of dengue are found in the hinterland regions. Actions that must be taken to control these vectors and the health conditions, such as malaria, diarrhoeal diseases and dengue include:

1. Reduction of potential breeding sites: drain water from all pools and fill with soil.

2. The sides of flowing streams in the vicinity of inhabitants should be treated with the appropriate insecticide.
3. Tins, bottles, tires, etc should be disposed of properly to prevent the accumulation of water (burying and punching holes in tins and tyres).
4. All refuse (garbage and rubbish) must be properly disposed of, by means of burning and burying).
5. All water used for various forms of consumption should be disinfected by the various "household methods," either by boiling or chlorinating before use.
6. In relation to chemical contaminants, miners must be encouraged to abort their indiscriminate use of chemical substances because of the deleterious effects of marine land human lives.

Additional Recommendations for GGMC

Overall GGMC will be responsible for monitoring and surveillance of policies while the Ministry of Health will assist in the implementation process.

1. Develop guidelines for camp conditions (size, and number of persons).
2. Review policies and set up Environmental Standards for mining camp, and communities in relation to solid waste management and protection of water sources (mercury).
3. Monitor contamination of water (mercury).
4. Develop sanctions on persons known to contaminate water source (heavy metals).
   - Miners to treat all water for drinking purposes in camps.
   - Miners to provide water containers with covers, and piped facilities to access water from containers.
5. GGMC to collaborate with the Departments of Health in each region, and Environmental Health Officers/Assistants to inspect camps frequently to maintain Environmental Standards.
6. GGMC to establish a form of registration of all miners (e.g. tracking of persons from previous to present locations). Screening to reduce the risk of malaria and dengue.

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