The neurotoxic consequences of methyl mercury poisoning for the inhabitants of Brownsweg, Surinam

Figure 1: gold mining operation in the Amazon rainforest, mongabay.com (2008)

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Summary

Mercury is a global pollutant and is widely used in Surinam at the gold mining industry in the Amazon rainforest. Mercury particles enter the human body through eating contaminated fish, and affect mainly the brain. Research shows that especially the developing brain is susceptible for the toxicity of mercury.

Up to the present, no research has been performed on the consequences of mercury poisoning for the inhabitants of the Surinam interior. This research project will be the first start. At all measurements, the local community will be involved as much as possible.

Approximately 100 school-going children and about 100 adults, coming from Brownsweg, Surinam, will undergo a neurobehavioral test battery. These test results will be linked to the mercury levels from taken hair samples by the National Zoological Collection of Surinam/Centre for Environmental Research of the Anton de Kom universiteit, Paramaribo. The question whether a relation exists between the scores on the neurobehavioral tests and the found mercury level in children's and adults hair samples will be analysed with a multiple regression model.

The results will be used to inform the inhabitants of Brownsweg about the harmful consequences of mercury ingestion. Also, this research will contribute in broadening the understanding on mercury toxicity in general. The results will be presented at different Surinamese ministries, namely regional development, natural resources and public health.

1 Background

1.1 Mercury

Mercury is a highly poisonous metal, which can be very harmful for the natural environment, especially in the form of methyl mercury. In mammals (including human beings) it can cause severe damage to the lungs, liver and the brain. Mainly the developing brain is very sensitive for the neurotoxicity of mercury (Clarkson, 1993; EPA, 2000; Castoldi et al., 2001).

In Surinam, gold miners use mercury for the amalgamation process to recover gold from the sediment. Every year, approximately 20 tons of mercury enters the natural environment (Mol et al., 2001). Once in the rivers it is transforms by micro organisms into the highly toxic methyl mercury, which is taken up by fish. Because it is hardly eliminated from the body, methyl mercury accumulates. Humans are exposed to methyl mercury through eating the contaminated fish. Besides processes involved with gold mining, mercury enters the water through natural processes of vegetation decomposition and natural accumulation (EPA, 2000).

The inhabitants of the villages of Surinam eat many self caught fish from the lakes and rivers. A positive relation is found between the measured mercury level in hair samples and the amount of fish villagers eat (Maim et al., 1995; Ouboter et al., 2007).
Different studies show that mercury exposure relates to brain damage (Grandjean et al., 1997; Lebel et al., 1997; Grandjean et al., 1999; Dolbec et al., 2000; Pinheiro et al., 2006). The results from Canadian (Wheatley et al., 2000) and Seychellois (Davidson et al., 2006) research do not show this relationship. In some cases, there even seems to be a positive relation. More research is needed to better understand the relation between mercury exposure and the neurotoxic consequences on human beings.

Up to now, almost no research on the effects of mercury poisoning has been performed in Surinam. The only research on this topic was from Mohan et al. (2005), where they studied the hair mercury levels of mothers and newborns in Suriname. The results showed a positive relation.

The current research will be the first project to investigate the effects of mercury poisoning on inhabitants of the Surinam interior, living near gold mining areas and eating mainly self caught fish.

1.2 Research project NZCS/CMO

The National Zoological Collection of Surinam (NZCS) is an institute of the Anton de Kom University of Surinam (AdeKUS). Its main task is to develop an overview of the Surinam fauna and build a reference collection for scientific and educational purposes. The collection is combined with scientific research. The Centre for Environmental Research (“Centrum voor Milieu Onderzoek”, CMO) carries out research on aquatic pollution among other things.

The NZCS/CMO personnel consists of 12 employees. In the last few years, the institute performed several projects, including water quality monitoring, research on the ecotoxicology of Surinamese water, and mercury research.

The research project on the neurotoxic consequences of methyl mercury poisoning is part of a larger research project from the NZCS/CMO and runs parallel with this data collection. Hair samples will be taken at 50 households of Brownsweg and the amount of mercury is determined in the laboratory. For the same participants, a fish consumption survey will be administered by the NZCS/CMO team.

The inhabitants of Brownsweg mainly eat fish from the Brokopondo lake. Fish will be caught there and analysed on mercury in the laboratory to develop a fish consumption list with relatively safe (low mercury) and unsafe (high mercury) fish. The main goal of the NZCS/CMO research project is to inform the locals about mercury poisoning and to give an alternative option for eating poisoned fish.

To show the villagers what the impact of eating the contaminated fish is, a complementary research on the neurotoxic consequences is needed.

1.3 Search request and hypotheses

Search request:

Does mercury poisoning through eating mercury containing fish cause brain damage for the inhabitants of Brownsweg?

From the literature it shows that mercury poisoning can be attended with several forms of brain damage. In the adult, methyl mercury poisoning is characterized by focal damage, mainly in the visual cortex, parts of the cerebellum and sensory nerve (Castoldi et al., 2001). Prenatal exposure shows a more diffuse and widespread damage to the brain (Clarkson, 1993).

Eight neurobehavioral tests that measure different brain functions, will be used to measure whether there is a relationship between the amount of mercury from hair samples and the test scores. It is expected that the neurobehavioral test scores will be negatively related with the mercury levels in hair samples.

2 Method

2.1 Participants

The research project will take place in Brownsweg, consisting of seven villages (Ganze, Makambi, Birudu, Kadjoe, Djanga Kondre, Wakibasu I, Wakibasu II). The inhabitants are Saramaccan, descendants of the African slaves who freed themselves from the plantations. The general language is Saramaccan, most people also speak Sranantongo and some speak Dutch. The primary school is in Dutch language.

A team from the NZCS/CMO will collect information of all the households of Brownsweg. This information includes: number of people in household, age, years living in the area, pregnant women, schoolgoing children, permission to cooperate in the research testing.

From these households, a selection of 50 will be made to participate in the study. Selectioncriteria are ‘giving permission to cooperate’, ‘having one or more children aged 6 to 12’ and ‘including one or more pregnant women’.

Approximately 50 households will participate in the hair sampling and fish consumption survey study. The adults of these households will be asked to fill in an informed consent form, in which they give permission to cooperate with the neurobehavioral testing for themselves and their children. The households will receive a small payment for participation.

Approximatly 100 children and 100 adults will participate in the neuro(psycho)logical testing.

2.2 Materials

After extensively studying the literature on neurotoxicity of mercury poisoning (Grandjean et al., 1997; Lebel et al., 1997; Grandjean et al., 1999; Dolbec et al., 2000; Drash et al., 2000; Cordier et al., 2002; Davidson et al., 2006; Murata et al., 2007; Castoldi et al., 2008) different neurological and neuropsychological tests are selected to be measured in this research. Also, a questionnaire is developed. The choice of neurobehavioral tests is based on previous test results and measure performance related to brain areas that are expected to be affected by mercury.

- A questionnaire will be filled in with questions concerning the following symptoms:
  Metallic taste, tiredness, headache, hypersalivation, excessive sweating, and insomnia.

- The neurological/medical testing will measure whether the following symptoms are present:
  Ataxia, tremor, disdiadochokinesis, dysarthria, blueish colored gums and disturbances in gross motor movement, coordination and perception. The results will be scored on a pre-printed form.

- The neuropsychological testing will measure the following aspects of brain functioning: attention, concentration, memory, visuospatial functioning, fine motor movement, motor speed, coordination, and early visual processing. The tests to be used are 5 existing (WISC-III digit span, WISC-III symbol search, M.T.B. Tapping, M.T.B. Dotting, and V.M.I.) and 2 self developed tests (Saramaccan memory test, Surinam picture naming test). The total test battery is expected to take 40 minutes to complete.
  The results will be scored on a pre-printed form.

Tabel 1 gives an overview of all the data to be collected.

Tabel 1: data collection for research project on neurotoxic consequences of methyl mercury

Background information	**Questionnaire**	**Neuro(psycho)logic testing**	
What factors can be of influence on the test results?	What symptoms can you expect to be reported by someone who is poisoned with mercury?	On what skills do you expect people with a mercury poison to perform worse than people without a mercury poisoning?	
Collected by NZCS/CMO team*	Collected by NZCS/CMO team*	Collected by the medical doctors**	Collected by resea assistants***
- Male/Female - Weight - Age - Occupation - Years of education - Months pregnant - Years living in area - Medical history - Fish species eaten - Wildlife eaten - Change in fish consumption pattern	- Metallic taste - Tiredness - Headach - Hypersalivation - Exessive swetting - Insomnia	- Ataxia - Coordination - Tremor - Visual acuity - Visual fields - Disdiadochokinesia - Dysartria - Reflexes - Blueish gums	- Picture Naming tes - Memory test (sh term and long te memory) - Hand coordination test - Attention/concentr on & work memory test - Visuospatial performance test - Motor speed test

- Proteïn intake - Breast-feeding - Smoking and drinking behavior during pregnancy			- Visual search test

* Natarain, Usha; Starke, Sheryl and Nanden, Indra.
** Dr. Kafiluddin, Eric; Dr. Yang, Harvey; Dr. Van der Harst, Joep; Baker, Marit.
*** Babel, Marilva; van Cooten, Telina; Jankipersad, Reshma; Treurniet, Gini.

2.2.1 Background information

Background information is collected from the participating adults, their children and about pregnancy with the participating children. All the questions from the interviews will be asked to the adults and are collected by the NZCS/CMO research team.

Questions for the adults: age, occupation, years of education, medical history, weight (measured with weighing scale), fish consumption history, years living in the area, alcohol use, smoking habits.

Questions about the participating child: age, grade, weight (measured with weighing scale), medical history, years living in the area.

Questions about prenatal period of participation child (pc): number of months pregnant with pc, breastfeeding, alcohol use during pregnancy pc, smoking habits during pregnancy pc, other specialties during pregnancy pc.

2.2.2 Neurological testing

A team of medical doctors will perform the neurological testing. The tests will be practiced and performed in a uniform way to augment objectivity of the test results. The different neurological tests relate to visual ability, motor behaviour and higher cerebral functions.

2.2.3 Neuropsychological testing

Seven (five existing and two newly developed tests) different neuropsychological tests will be used.

Wechsler Intelligence Scale for Children – III
The WISC III is a general intelligence test for children aged 6 to 16. It consists of 13 subtests that measure different aspects of intelligence. The subtests ‘ Symbol search, part A’ and ‘Digit Span forwards and backwards condition’ are used.

- *Symbol Search*
  Deciding whether target symbols appear in a row of symbols and marking it YES or NO accordingly.
- *Digit Span*
  Repeating dictated series of digits (e.g. 4 1 7 9) forwards and other series backwards. Series begin with two digits and keep increasing in length, with two trials at each length. This test measures attention and working memory.

Manual Test series Both consists of seven subtests and are all measuring motor performance. The tests used are
‘Tapping’ and ‘ Dotting’:

- *Tapping*

In this test the subject is asked to put three dots in one circle with a felt-pen. The subject receives 45 seconds to complete as many circles as possible. This test principally measures motor speed and accuracy.

- *Dotting*
  The subject is asked to mark each circle on a line with a felt-pen. The distances between circles are different. The score is the amount of correct marked circles within 45 seconds. The test mainly measures hand-eye coordination and accuracy.

- *Beery Visual Motor Integration*
  The Beery V.M.I. test helps assess the extent to which individuals can integrate their visual and motor abilities. The subject is asked to copy the presented drawings of geometric forms arranged in order of increasing difficulty.

- *Saramaccan Memory Task*
  This memory task shows the participant 16 pictures of familiar objects for Saramaccan people, divided in four categories (clothes, fruit, wooden objects and vehicles). The research assistant shows and names all pictures and asks the participant which pictures he/she can remember. This procedure is repeated three times.
  After an interval of approximately 25 minutes, the participant is asked again which pictures he/she can remember (recall condition). Subsequently the research assistant shows multiple choice item, in which the participant points to the picture he/she previously saw (recognition condition).

- *Surinam Picture Naming Test*
  The subject is asked to give the names of 40 different objects, shown as colour photos and drawings. If the subject doesn't know the right answer, the first letter of the name in Dutch is given. Since the inhabitants of the villages are bilingual, the language in which the answer is given doesn't matter.

2.3 Procedure

Preparing

*** Before the test period**

- The captains of Brownsweg will be asked for permission to carry out the research in their villages. A suitable testing room per village is selected (for example the place where the village has it's meetings) and arrangements are made to use this room in the testing weeks;
- 50 households will be selected to participate in the research;
- The two local schools will be asked for permission to make use of a class room for testing the children. The schools will receive a small payment for using their space;
- The NZCS/CMO team will be asked to do the interviews;
- Medical doctors are informed about the research through the Medical Scientific Institute of Paramaribo;
- Four research assistants are recruited in Paramaribo. Preferably it will be students from social sciences, who speak fluently Sranantongo.

*** Meetings**

- The interviewers will be trained in collected the background information and questionnaire. The questions will be practiced and obscurities will be clarified. The interviewers receive a small payment for attending the training.

- The group of medical doctors and research coordinator will come together three times to discuss their contribution to the research project. The different neurological tests will be practiced to in a uniform fashion and make arrangements about the different tests used. The forms will be
- The research assistants will be trained and testing will be practiced in detail. The test examiners will receive a small payment for attending each training.

*** Preliminary research**

For developing the Saramaccan Memory Task and the Surinam Picture Naming Test, a preliminary research is necessary. Two primary schools, one boarding school and several people at home will participate. The children and adults are preferably Saramaccan. In total about 100 children and 60 adults will participate.
The results will be used to develop the new tests and practice and optimize the existing tests (selecting the pictures, choosing the writing materials, developing the scoring forms, writing the manual, etc.)

The preliminary research is a good practice for the research assistants. This way they will be fully prepared to take the tests when in the field.

Data collection

Children – neuropsychological testing:
About ten children will be tested per day by the research assistants. Testing will take place in the local schools, during school time in the hired test room (a storage accomodation).

Children – neurological testing:
Approximatly ten children will undergo the neurological testing per day. This will take place in the school, in a different room than the neuropsychological testing.

Adults – neuropsychological testing:
About ten adults will be tested per day by the research assistants. Testing will take place in the villages. Every village had its own testing place.

Adults – neurological testing:
Approximatly ten adults will be tested per day by the medical doctors. Testing will take place in the reserved areas from each village.

For all tests, the research assistants, medical doctors and research coordinator are unaware of the mercury levels from the hair samples of the participants. In ten testing days, at least 100 children and 100 adults undergo the neurological and neuropsychological testing.

The datacollection will consist of five parts:

Selection of participating households	April 3rd to April 9th
Hair sampling, fish consumption survey, and background factors (dry season)	April 27th to May 4th
Neuro(psycho)logical testing part one	**May 10th to May 15th**
Neuro(psycho)logical testing part two	**May 24th to May 29th**
Hair sampling, fish consumption survey, and backgrond factors (rainy season)	June

Neuro(psycho)logical testing

The research team:

Research coordinator	: Kooreman, L., MSc.
Research assistants	: Telina van Cooten (sociology student), Reshma Jankipersad (environmental science student), Marilva Babel (sociology student) and Gini Treurniet (education science st.)
Neurologist	: Dr. Kafiluddin, E.
Medical doctor, week 1	: Dr. Yang, H.
Medical doctor, week 2	: Dr. van der Harst, J.
Medical doctor, week 2	: Baker, M., ergotherapist
Busdriver	: from 'Ricky's'

Field trip starts on a Sunday. A bus will bring the research team from the university complex to Ston Island, where they stay five nights. This camp is surrounded by a beautifull lake and the accomodations are small huts. Toilet and kitchen are available. Food will be delivered or made there. Ston Island is approximately a 15 minute drive from Brownsweg. Table 2 gives an overview of each field trip according neuro(psycho)logical testing.

Table 2: field trip overview Monday to Friday

Time	**Location**	**Activity**	**Researchers**
8:00 – 13:00	RK school	Neuropsychological testing: children	1 research assistent
8:00 – 13:00	EBG school	Neuropsychological testing: children	1 research assistent
8:00 – 13:00	Villages	Neurological/medical testing: adults	medical doctor neurologist (1 day,week1) ergotherapist (week 2)
13:00 – 15:00	*Ston Island*	*Break*	*Complete team*
15:00 – 17:00	Ston Island	Data scoring + data entry	2 research assistents
15:00 – 17:00	Villages	Neurological/medical testing: children	Medical doctor Ergotherapist (week 2)

3 Results

3.1 Data analyses

*** Neurobehavioral data and mercury data**
The data from the mercury measurements and the neurobehavioral testing will be joined in SPSS.

*** Exclusion criteria**
A participant will be kept out of the analysis if he/she:

- has had a neurological disease that cannot be contributed to mercury poisoning (e.g. encephalitis)
- has had an accident with neurological damage (e.g. car accident with brain lesion)
- has a psychiatric disease (e.g. schizophrenia)

- has a physical handicap that interferes with testing (e.g. blind)

*** Multipele regression analyses**
A hierarchical multiple regression model will be used to analyse the relation between the test scores and the mercury levels. The contribution of mercury level on the test scores is assessed after controlling for confounding variables (e.g. age, sex and educational level).

The minimal sample size for using multiple regression is N > 50 + 8m (where m = number of independent variables) (Tabachinick and Fidell, 2001). In this research the number of independent variables will be between 1 and 7.

- Mercury level
- Age
- Sex
- Educational level
- Drinking behaviour
- Children: months breastfeeding, prenatal months

3.2 Presentation results

*** Writing article and publication**

*** Summarize and article and make it understandable for the villages' captains**
The article will be summarized so it is comprehensible for non-scientists. The results will be summarized with pictures and printed on a poster and/or folder.

4 Timetable and budget

Table 3 gives an overview of the research planning and budget. The second column shows the budget in USD. The third column gives the amount of months assigned to each project division.

Table 3: research budget and planning in months

	Costs in USD	**Planning in months**
Development testbattery (sheet 2 for details)		
Preliminary investigation	249	March – April
Main research	527	April – May
Employment costs (sheet 3 for details)		
Research coordinator, 1239 hours	15480	November – August
Research assistent 1, 209 hours	600	March – May
Research assistent 2, 209 hours	600	March – May
Research assistent 3, 209 hours	600	March – May
Research assistent 4, 209 hours	600	March – May
Neurologic testing	500	April – May

Interviewers	480	April
Driver (incl bus + fuel)	1181	May
Fieldtrip expenses		
Phone costs	75	May
Nights of stay	814	May
Food	1100	May
Other costs		
Payment participating households	500	May
Payment participating schools Browsweg	150	May
Payment participating schools preliminary investigation	91	March – April
Public transport	27	March – April
Information session Brownsweg March 13th 2009	201	March
Total costs	**23780**	

Payment schedule consultancy expenses:
Payment 1: research assistant fees for work in Februari-March (757), test battery preliminary investigation (248), information session Brownsweg (201), payment schools preliminary investigation (91), public transport (27), driver (1181).
Total USD **2,505.00**

Payment 2: research assistant fees for work in April-May (1643), neurologic testing (500), field expenses (1989), interviewers (480), payment participating households (500), payment participating schools (150), test battery main research (527).
Total USD **5,789.00**

Total expenses are USD 2,505 + 5,789 = **USD 8,294**

5 Literature

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