MINAMATA ONLINE

SEASON 2 - 2021 2022

HEALTH RISKS OF MERCURY IN THE CONTEXT OF GLOBAL SOCIO-ENVIRONMENTAL VARIABILITY

MINAMATA CONVENTION ON MERCURY

This fourth session of the mercury science stream addresses human health risks to mercury in the context of worldwide socio-environmental variability. This topic, in preparation for the 2022 ICMGP plenary lecture and synthesis paper, presents an overview of risks posed by mercury to human populations worldwide through case studies. We tend to generalize (and at times misrepresent) mercury risk in science and policy arenas and can sometimes forget that risk is context dependent. As such, the primary goal of this work is to help stakeholders (e.g., Minamata Convention policy makers; mercury scientists) gain a deeper empathy and understanding of the diversity/variance of mercury risk globally.

SPEAKERS

Masatake Fujimura
Director, National Institute for Minamata Disease, Japan

Emelyn Shroff
Director of Research, Public Health Authority, Seychelles

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Milena Horvat
Head, Department of Environmental Sciences, Jožef Stefan Institute

Joy Leaner
Co-chair, International Conference on Mercury as a Global Pollutant 2022

Eisaku Toda
Secretariat of the Minamata Convention on Mercury

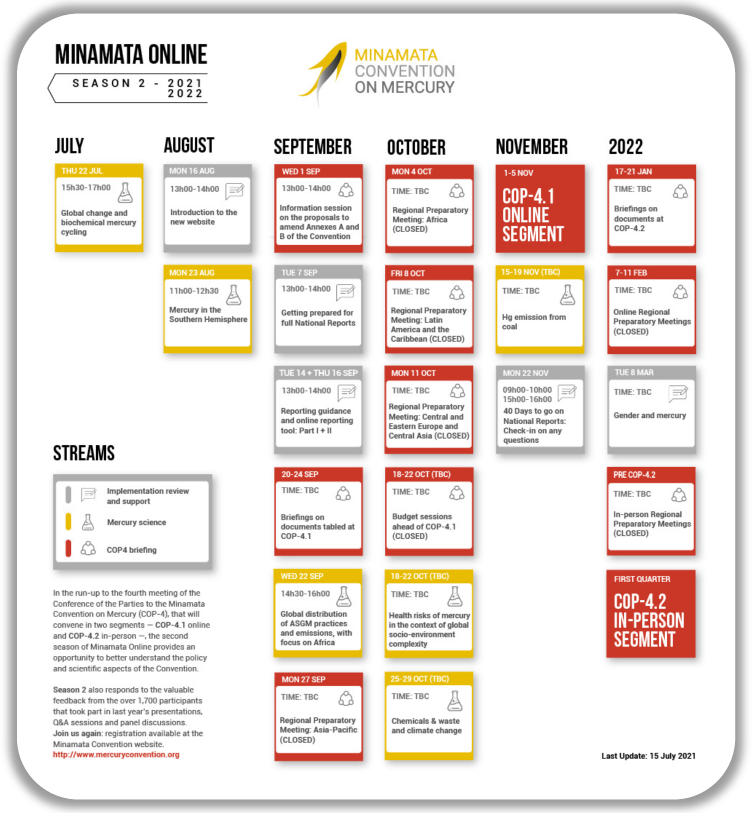
TUESDAY, 19 OCT. 2021
14h00-15h30 CEST

REGISTER NOW

Please register for the WebEx session using the links above.

Information about Minamata Online

Check the Season 2 calendar

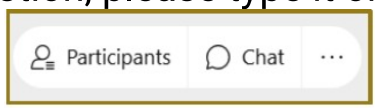


MERCURY SCIENCE

Housekeeping notes

- You may wish to test (and adjust) your **speaker and microphone settings** by opening the **Audio & Video** menu at the top-left corner of your screen.

- You can open the **Participants** panel and the **Chat** panel by clicking the respective icon at the bottom-right corner of your screen. If you have any question, please type it on the **Q&A panel**, and send it to all panelists, by clicking on the ellipsis (…).



- There may be time for oral questions. If the moderator invites some, and if you wish to take the floor, please click the **Raise Hand** icon that appears next to your name on the Participants panel. The Secretariat will unmute you after the moderator names you. When your speaking is over, kindly **mute** yourself and click the **Lower Hand** icon.

- If you need any technical assistance, please put your message in the chat box and send it to the host.

- Kindly note that this session is **recorded and broadcasted**. Recording of this session and the presentation slides will be made available through the Minamata Convention website after the session.

ICMGP

MERCURY AS A GLOBAL POLLUTANT
24TH - 29TH JULY 2022
VIRTUAL EVENT

REDUCING MERCURY TO ACHIEVE A GREENER WORLD

https://www.ilmexhibitions.com/mercury2022/

Joy Leaner (PhD)
Minamata Online Season 2

ICMGP | MERCURY AS A GLOBAL POLLUTANT
24TH - 29TH JULY 2022
VIRTUAL EVENT
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ICMGP
MERCURY AS A GLOBAL POLLUTANT

Mercury Workshops: Call for workshop mini proposals and presenters

CLOSED

The ICMGP organises the ICGMP 2022 Mercury Workshops to allow an interactive experience for learning everything about mercury – including tackling challenging mercury issues, identifying best practices and methods, as well as gaining insights on the ... **Read More**

ICMGP
MERCURY AS A GLOBAL POLLUTANT

Lifetime Achievement Award

CLOSED

The Scientific Steering Committee (SSC) of the 15th International Conference on Mercury as a Global Pollutant (ICMGP 2022) to be held in July 2022 in Cape Town, South Africa is now accepting nominations for the Kathryn R. Mahaffey Lifetime Achievement Award in Mercury Research. This award was established in 2011 to celebrate and recognize selected individuals who ... **Read More**

ICMGP
MERCURY AS A GLOBAL POLLUTANT

Emerging Researcher Award in Mercury as a Global Pollutant

CLOSED

The Executive Committee of the 15th International Conference on Mercury as a Global Pollutant (ICMGP 2022) to be held in July 2022 in Cape Town, South Africa is now accepting nominations for its Emerging Researcher Award in Mercury as a Global Pollutant. Recognizing and celebrating important contributions of a ... **Read More**

ICMGP
MERCURY AS A GLOBAL POLLUTANT

Call for Special Sessions

The Executive Committee of the 15th International Conference on Mercury as a Global Pollutant 2022 ICMGP 2022 from 24 29 July 2022, invites you to share your work, ideas, research, and challenges by submitting a proposal for the Special Sessions themes and topics of the conference.The overarching theme of ICMGP 2022 is Reducing Mercury to Achieve a Greener ... **Read More**

Due date: 30 October 2021

lynwill.martin@weathersa.co.za

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ICMGP Cape Town 2024

Hg

THE 16TH INTERNATIONAL CONFERENCE ON MERCURY AS A GLOBAL POLLUTANT

WORK-IN-PROGRESS

Health risks of mercury in the context of global socio-environmental variability

ICMGP 2022 synthesis paper on human health

Minamata Online

October 19, 2021

Team Members

- Niladri Basu. PhD. Professor, McGill University, Canada
- Jose Dorea. PhD. Professor Emeritus, University of Brasilia, Brazil
- Masatake Fujimura. PhD. Director, National Institute for Minamata Disease, Japan
- Milena Horvat. PhD. Professor and Dean, Jožef Stefan Institute, Slovenia
- Emelyn Shroff, PhD. Director of Research Public Health Authority, Seychelles
- Irina Zastenskaya, MD/PhD. Technical Officer for Chemical Safety, WHO Regional Office for Europe, Germany
- Pál Weihe, MD. University of the Faroe Islands and Department of Occupational Medicine and Public Health, Faroe Islands

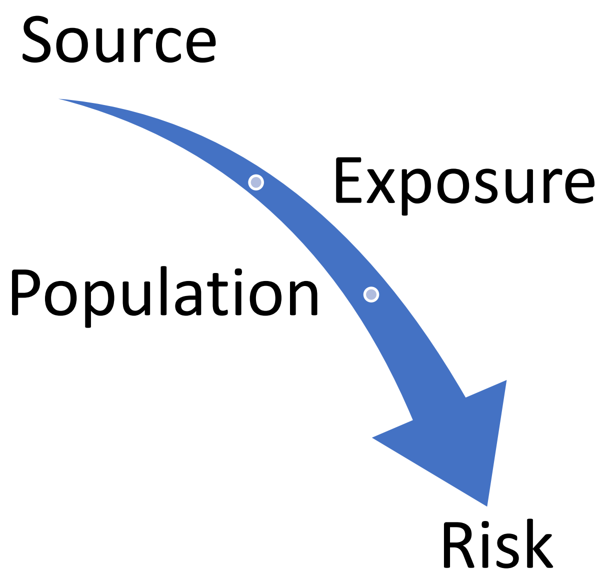
Outline

- Background and Justification
- Objective
- Case Studies
- Concluding Remarks
- Q&A Discussion

Background

- Minamata Convention Article 1 = "protect human health"
- Vulnerable groups mentioned often (Preamble text, Articles 16, 18, 19, 22, Annex C)
- Generally, we know that Hg is a risk to human health…
- Hg science and risk is evolving (from acute poisoning events, to focused cohort studies, to more diverse studies nowadays that capture a range of Hg sources, geographic and population groups, harness proactive and harmonized research and biomonitoring, and consider key socio-economic-environmental factors that underpin health)

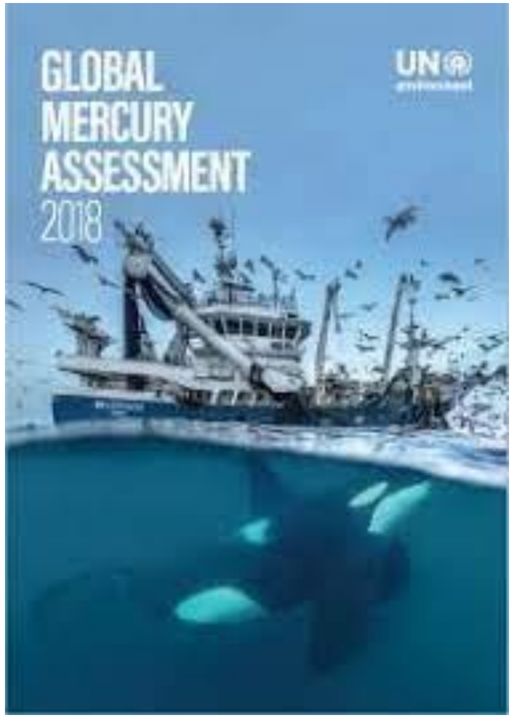
Risk ≠ Risk ≠ Risk

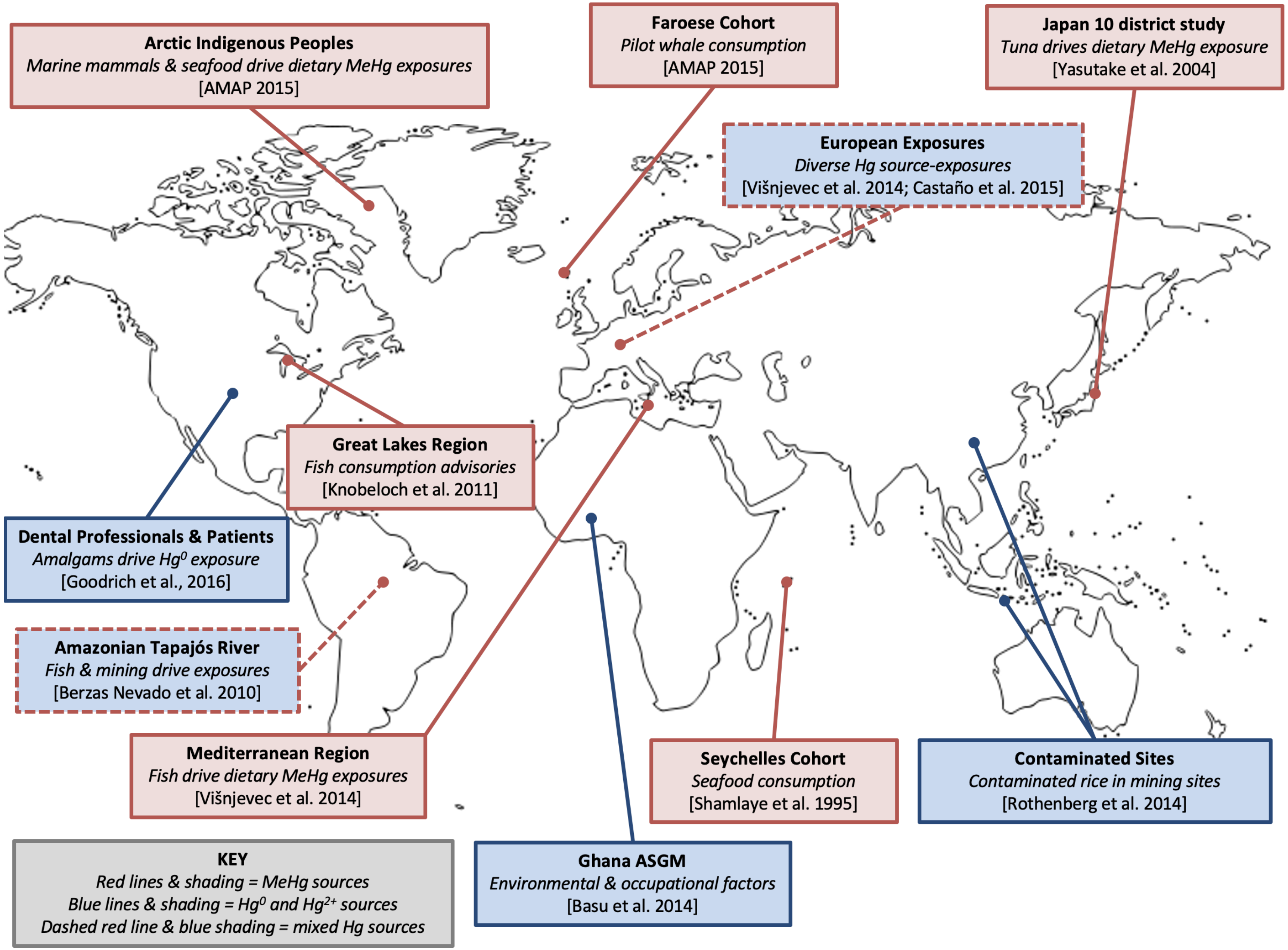


- MeHg ≠ Hg^{2+} ≠ Hg^0
- ingestion ≠ inhalation ≠ dermal
- tuna ≠ salmon ≠ rice ≠ seal meat
- tuna ≠ tuna ≠ tuna ≠ tuna
- children ≠ adults; males ≠ females
- rich ≠ poor; healthy ≠ sick
- Japanese ≠ Inuit ≠ Seychellois ≠ Canadians
- Canada ≠ Ghana ≠ India
- Obvious but…

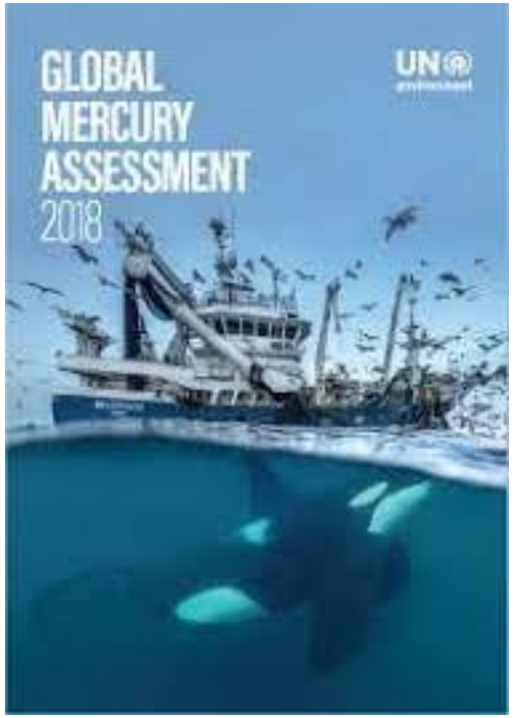
Background

- We tend to generalize (and sometimes misrepresent) Hg risk in scientific and policy arenas, but risk is context dependent
- Presence of Hg complicates situations of societal value (e.g., fish consumption and food security, mining and economic development, dentistry and oral health), but these vary worldwide
- Thus, operationalizing the Convention requires empathy and understanding of diversity/variance of populations worldwide, and in particular socio-environmental aspects

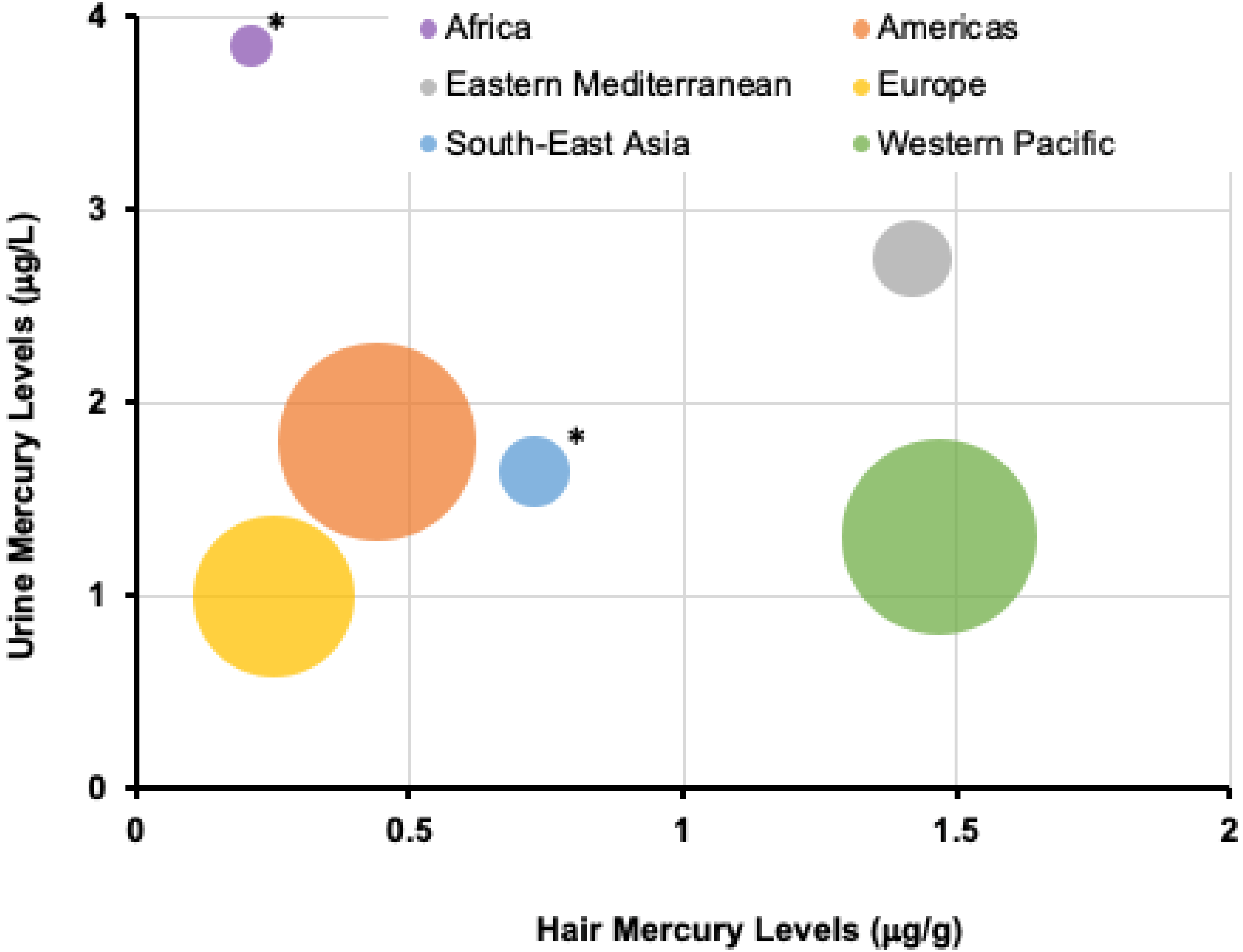




Hg sources and stories vary across the world…



... as does Hg exposure and risk

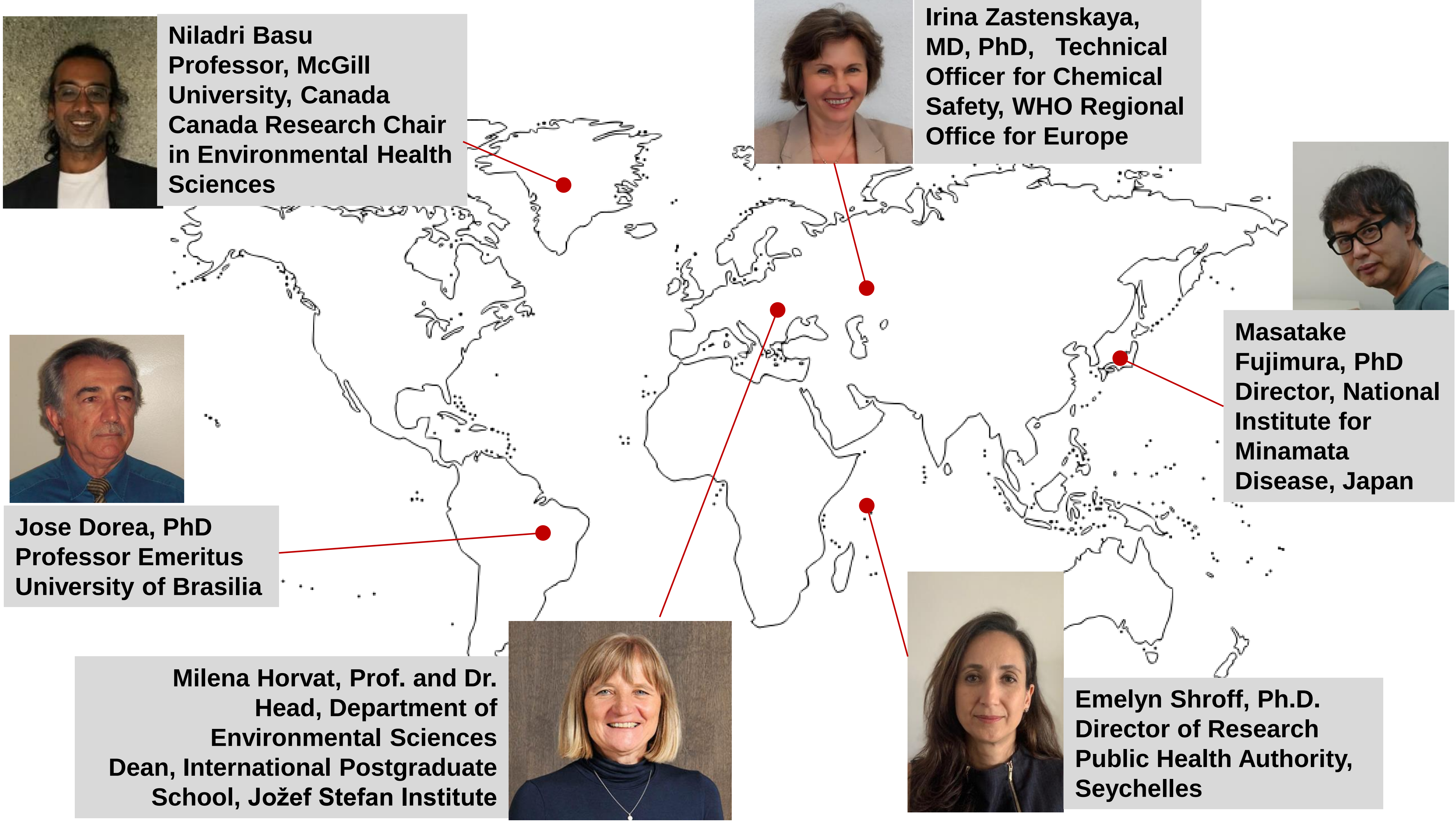


Objective of ICMGP Synthesis Paper

- To help stakeholders (e.g., Hg scientists, Minamata Convention policy makers) gain a deeper empathy and understanding of the diversity/variance of Hg risk in populations worldwide --- from the past to the present to the future.

- Present compelling "socio-environmental" case studies by leading experts

- Synthesize the information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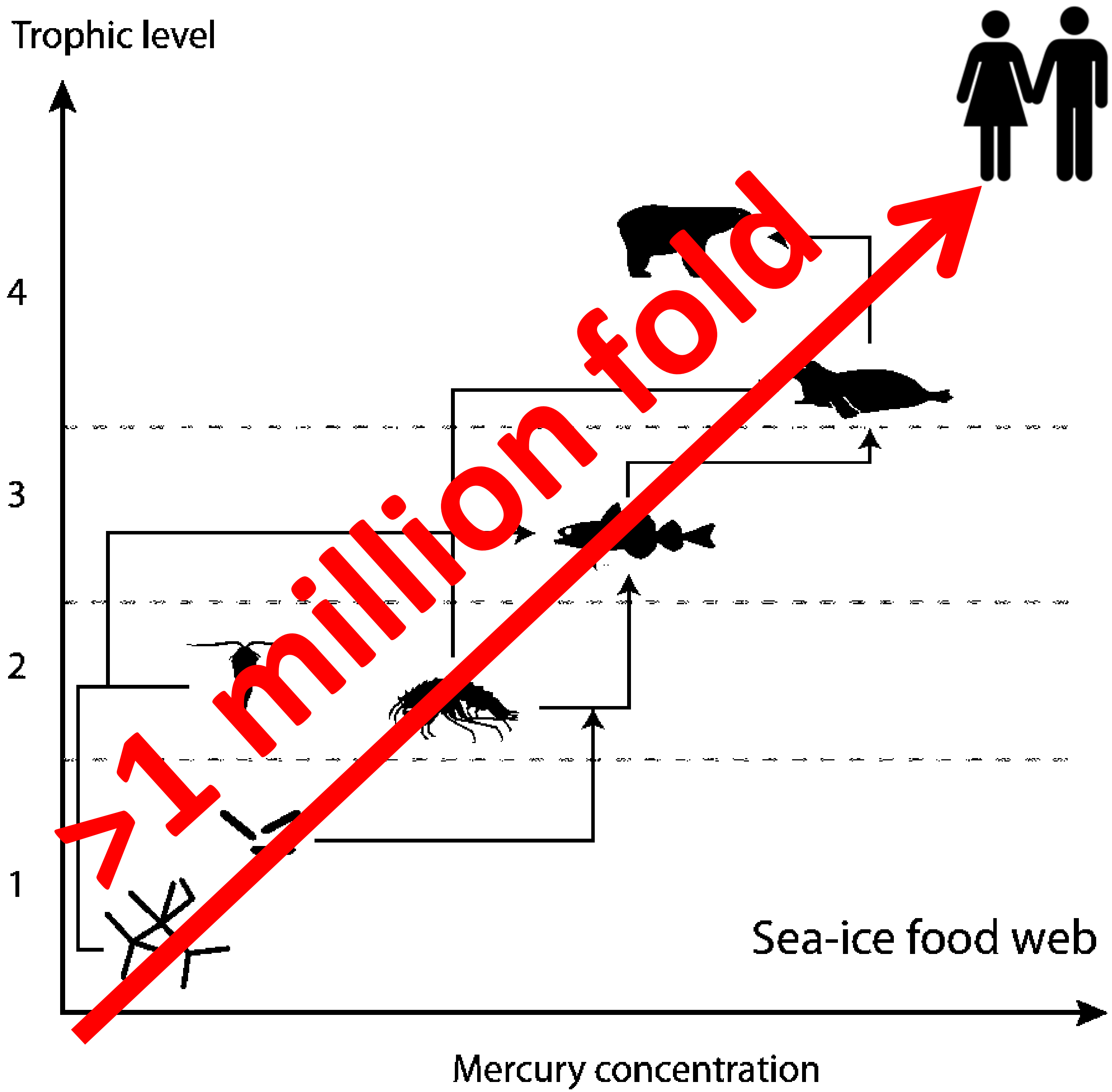
Arctic - background

- human health impacts of Hg on Arctic populations remains of worldwide concern as exemplified by the preamble text of the Minamata Convention which notes “the particular vulnerabilities of Arctic ecosystems and Indigenous communities”
- finding by the 2018 UN Global Mercury Assessment that human communities in the Arctic are among the most highly exposed to Hg worldwide
- the most relevant form for Arctic communities is methylmercury (MeHg) through consumption of traditional foods



Climate change?

AMAP 2011 Mercury Report

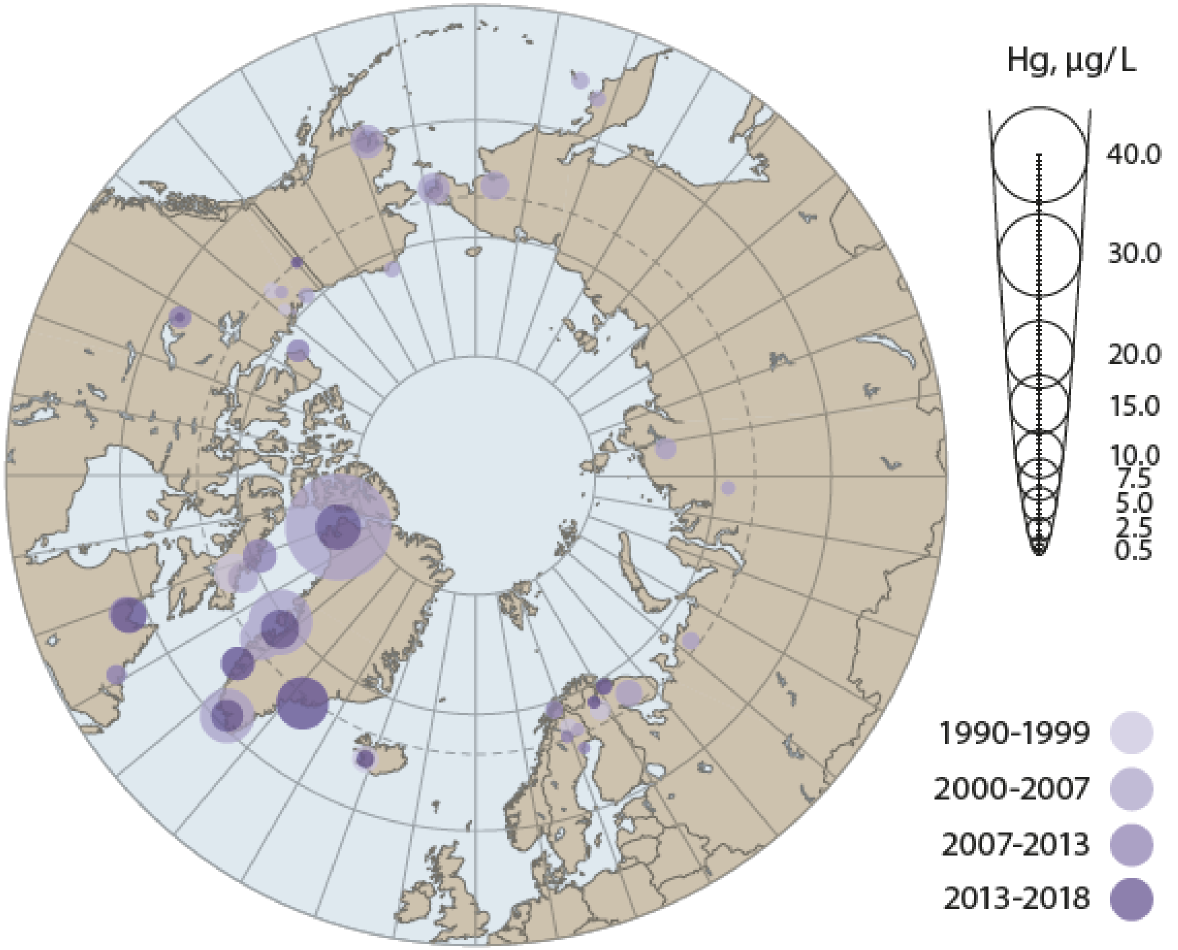
Tremendous dietary exposures

Food Item	Number of locations	Number of samples	Minimum (THg)	Median (THg)	Maximum (THg)	Dietary Intake of Food Item (g/week)
Ringed seal liver	19	1642	0.37	4.66	37.18	33 (IPY), 9 (Nunavik), 65 (Greenland)
Ringed seal muscle	12	1279	0.05[a]	0.37	0.89[a]	150 (IPY), 38 (Nunavik), 60 (Greenland)
Beluga muktuk	5	110	0.28	0.77	1.58	77 (IPY), 42 (Nunavik), 1.3 (Greenland)
Narwhal muktuk	1	20	0.59	0.32	0.85	31 (IPY), 1.3 (Greenland)
Arctic char (marine) muscle	4	547	0.07	0.18	0.75	
Arctic char (inland) muscle	35	1922	0.06	0.11	0.34	380 (IPY), 173 (Nunavik)

AMAP 2021 Mercury Report (forthcoming)

Arctic – Hg biomarkers

- Mercury concentrations in blood of mothers, pregnant women and women of child-bearing age in Arctic communities monitored in different periods since the 1990s under the AMAP human health blood monitoring programme, showing generally decreasing levels of mercury, in particular in those communities that exhibited high levels of exposure in the 1990s



AMAP 2021 Mercury Report (forthcoming)

Dietary Transition

- Traditional food is key to spiritual, cultural, physical well being
- But, there is a move towards store-bought foods (more accessible; food insecurity) along with concerns over contaminants
- These likely drive reductions in Hg exposure and biomarker levels

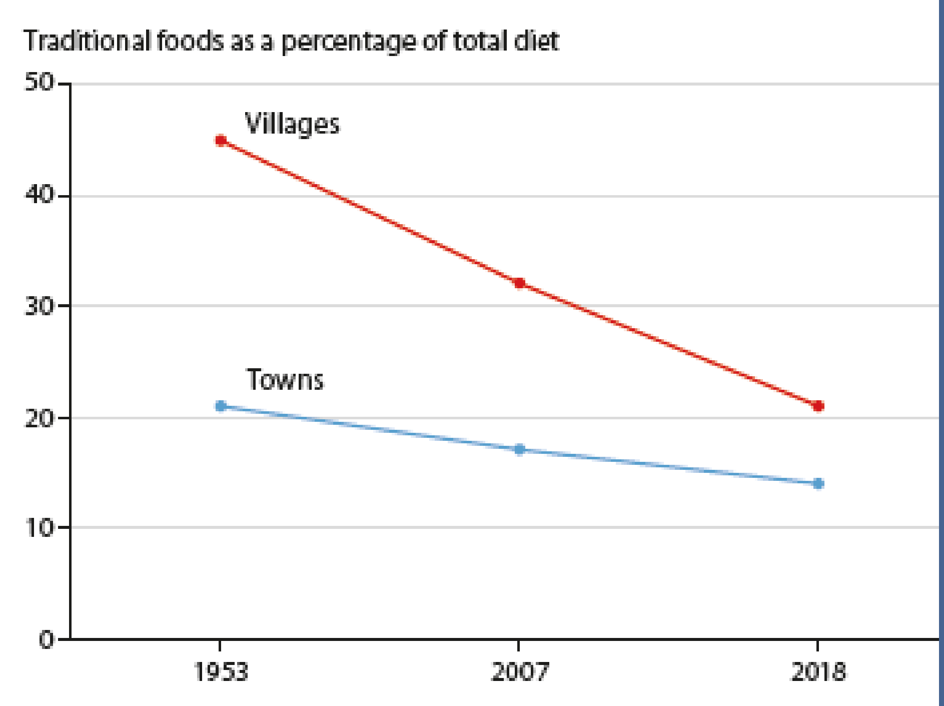
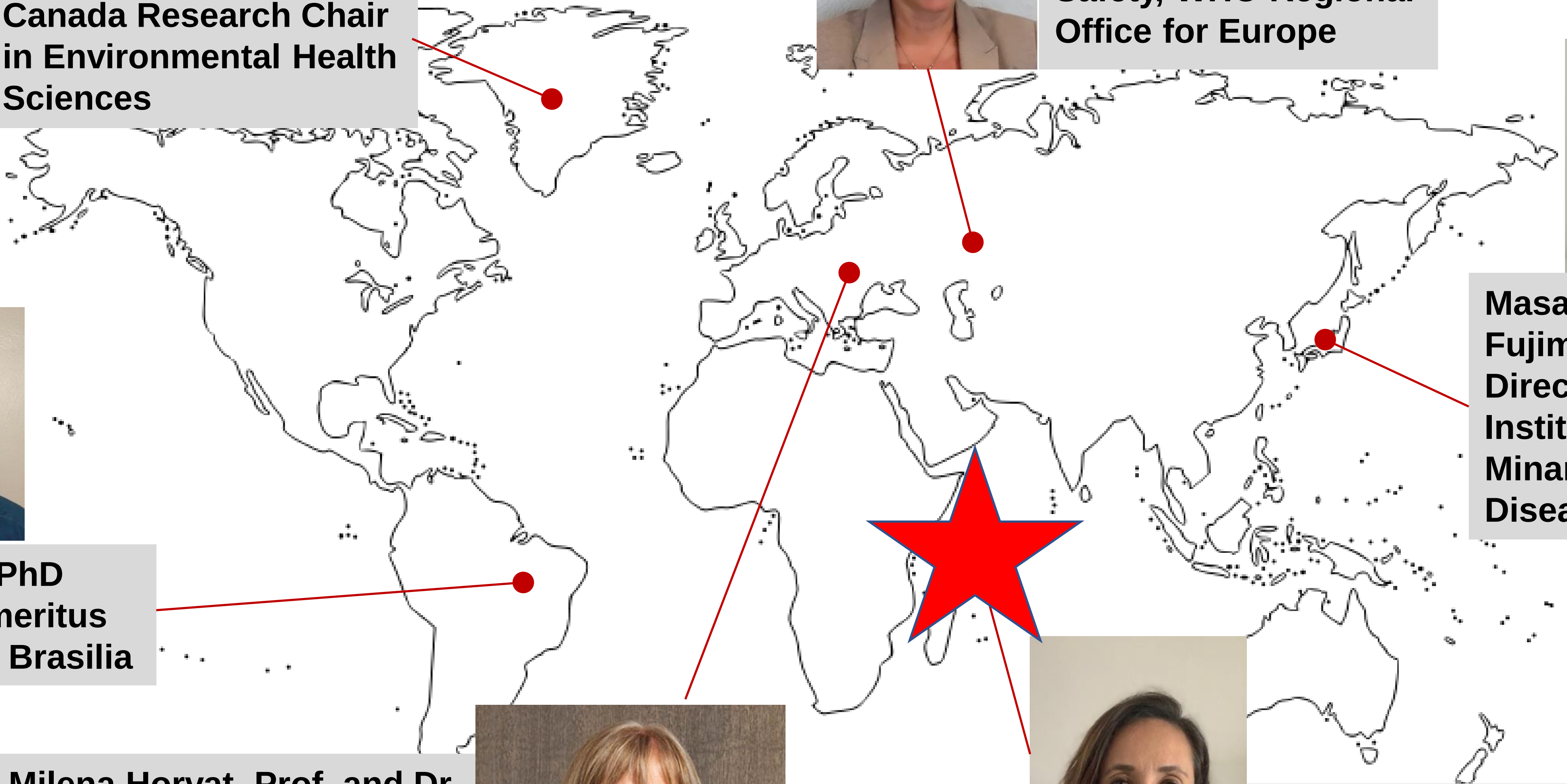


Figure 1. Consumption of traditional foods in Greenland towns and villages, 1953–2018.

2021 AMAP Human Health Report – Summary for Policy Makers

Arctic – Hg risk

- Epidemiological cohort studies on Arctic populations have been among the most influential worldwide in terms of demonstrating the link between early-life Hg exposure and later-life adverse health outcomes
- Studies in the Faroe Islands and Nunavik are exemplary
- Strong evidence of neurodevelopment and cardiovascular impacts
- Negative confounding by benefits afforded by a traditional diet and the nutrients that this diet contains
- risk communication is key, but not an easy undertaking or a permanent solution



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The Seychelles Experience

- High fish consuming nation
  - 57kg/person/year (~ 10 fish meals/week)
- Longitudinal studies over 30 years studying prenatal and postnatal Methyl Mercury exposures through fish consumption in multiple cohorts
- Ideal epidemiological site
  - Minimal industry/environmental pollution
  - Consumption of sea mammal is illegal
  - Education and Health are universally free and available
  - High retention rate of participants to study (80-90%)

To study child development in the Republic of Seychelles and to understand the influence of methyl mercury from fish consumption on children’s health and development

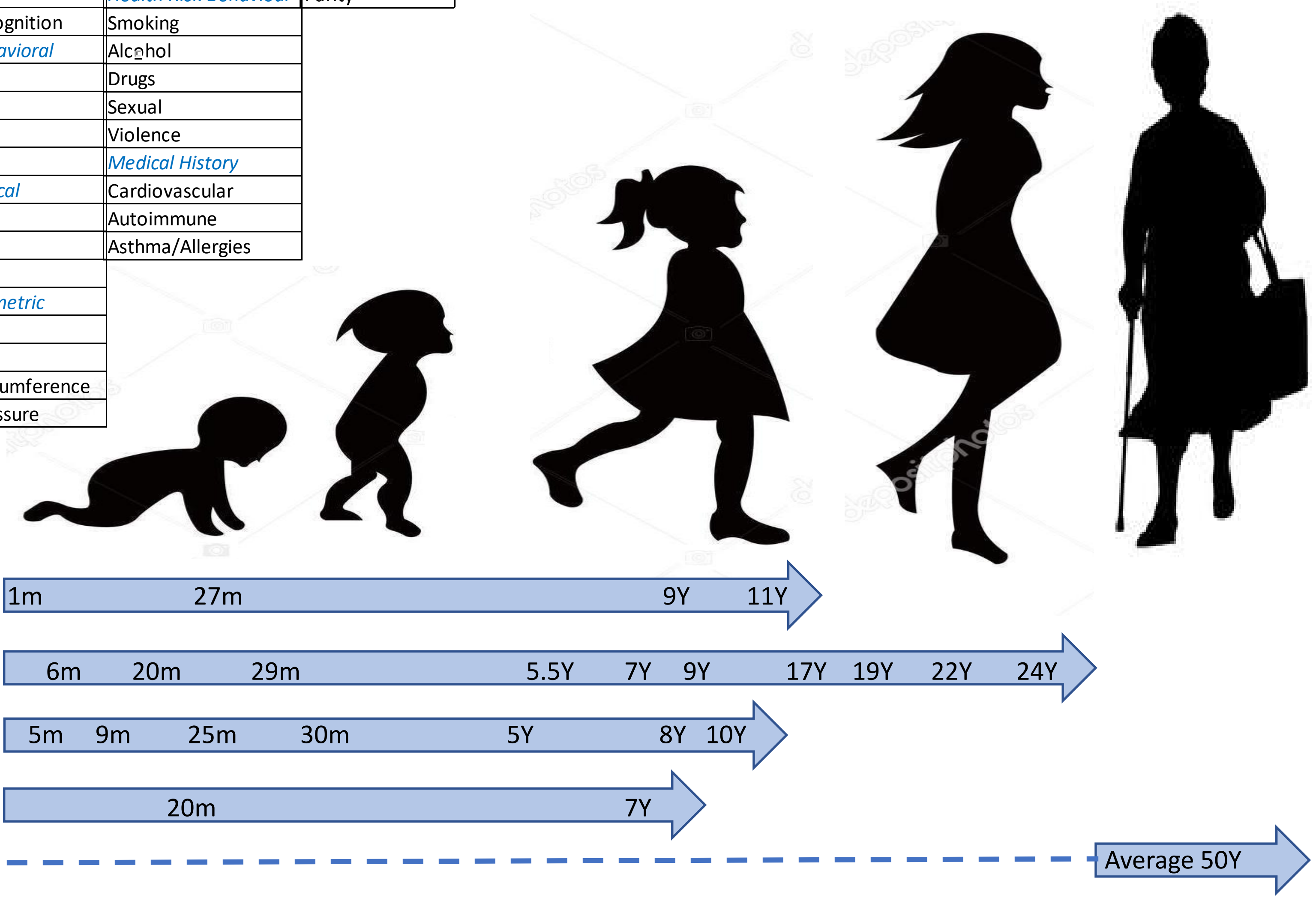
Prenatal

Postnatal

Biosample	Assessment	Survey	Demographic
Mercury Exposure	*Neurodevelopmental*	*Diet*	Age
Hair Hg	Executive function	Fish Use	Sex
Blood Hg	Psycomotor	Food Frequency	Hollingshead SES
Nutrients	Attention	Diary	Marital Status
PUFA	Memory	*Health Risk Behaviour*	Parity
Selenium	General cognition	Smoking	
Vitamin E	*Neurobehavioral*	Alcohol	
Iron	SRS	Drugs	
Choline	SCQ	Sexual	
Immune Function	CTRS	Violence	
Cytokines	CBCL	*Medical History*	
ANA	*Physiological*	Cardiovascular	
Immunoglobulins	OAE	Autoimmune	
CRP	BAER	Asthma/Allergies	
Genetic	HRV		
GSH	*Anthropometric*		
ABC	Height		
FADS	Weight		
mtDNAcn	Waist Circumference		
Telomere length	Blood Pressure		

Maternal Hair Hg: 1-30ppm
Mean: 6.8ppm

Mother assessed:
1st , 2nd , 3rd Trimester



Cohorts	No	Year	H	B	CB	FD	DA
Pilot	789	1987	✓				
Main	779	1989-90	✓	✓		✓	
NC1	276	2000	✓	✓	✓	✓	✓
NC2	1328	2008-11	✓	✓	✓	✓	
Mothers of Main	662	2013	✓			✓	

H: Hair, B:Blood, CB: Cord Blood, FD: Food Diary, DA: Dental Amalgam

Prenatal

Postnatal

NO ADVERSE EFFECTS ON NEURODEVELOPMENT OUTCOME AMONGST CHILDREN AND YOUNG ADULTS FROM PRENATAL EXPOSURE

Maternal Hair Hg: 1-30ppm
Mean: 6.8ppm

Mother assessed:
1st , 2nd , 3rd Trimester

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H: Hair, B:Blood, CB: Cord Blood, FD: Food Diary, DA: Dental Amalgam

1m 27m 9Y 11Y

6m 20m 29m 5.5Y 7Y 9Y 17Y 19Y 22Y 24Y

5m 9m 25m 30m 5Y 8Y 10Y

20m 7Y

Average 50Y

KEY FINDINGS:

Nutrients in fish:

- n-3 long-chain polyunsaturated fatty acids (PUFA) is beneficial for brain development may be playing a key role in modifying the influences of MeHg.
  Davidson PW et al,2003 , Strain JJ et al, 2008

- Selenium may be sequestering MeHg and alter its toxicity

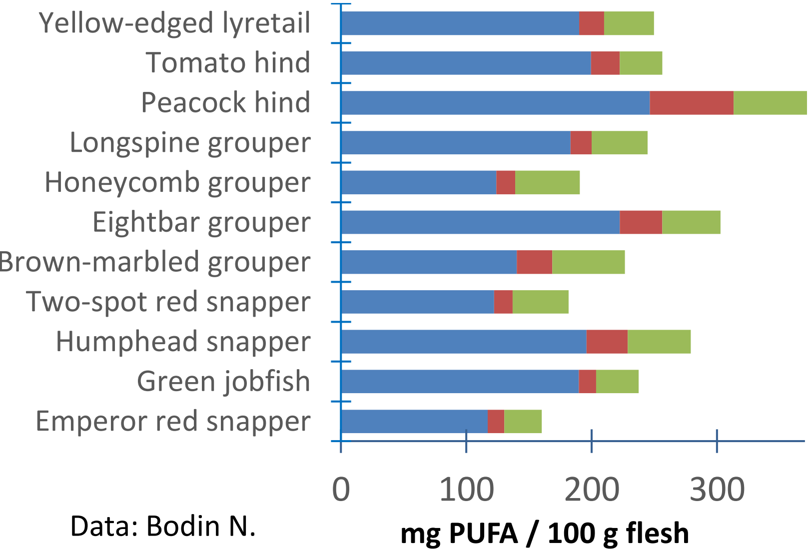
Genetics studies:

- Polymorphism in genes responsible for the transport and excretion of Mercury
  Engstrom K et al 2016, Prince L. et al 2014, Wahlberg K et al 2018
- Genes associated with PUFA metabolisms influence serum PUFA concentration
  Yeates AJ et al 2015

Important nutrients found in fish

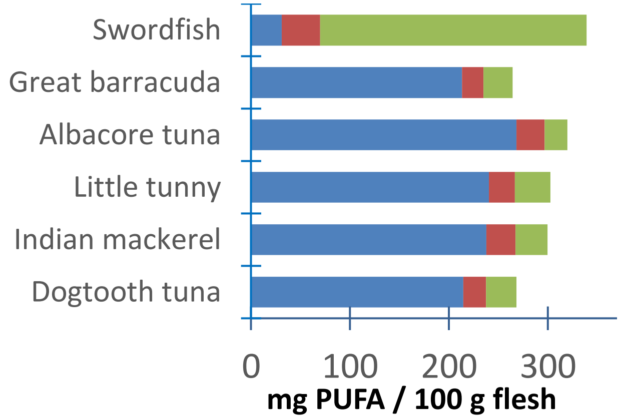
Macronutrients		Micronutrients		
Proteins	Lipids	Vitamins	Minerals	
			Microelements	Macroelements
Essential amino acids:	*Essential fatty acids (omega-3 & -6):*	D	*Essential trace minerals:*	Calcium
Lysine	DHA	B12	Zinc	Chlorine
Leucine	EPA	B6	Iron	Magnesium
Valine	ALA	A	Selenium	Phosphorus
Isoleucine	LA	E	Copper	Potassium
Threonine	ARA		Cobalt	Sodium
Phenylalanine			Iodine	
Histidine				
Methionine				
Tryptophan				

Demersal Species

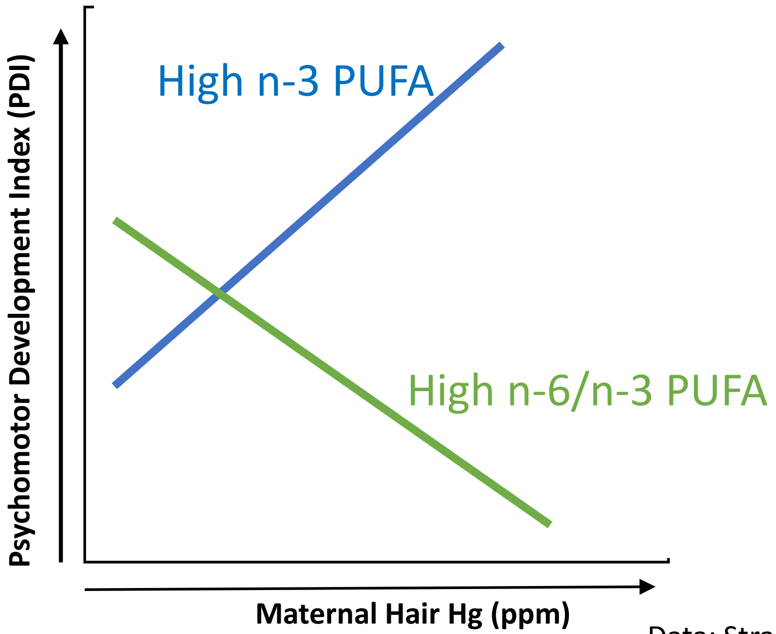


Data: Bodin N.

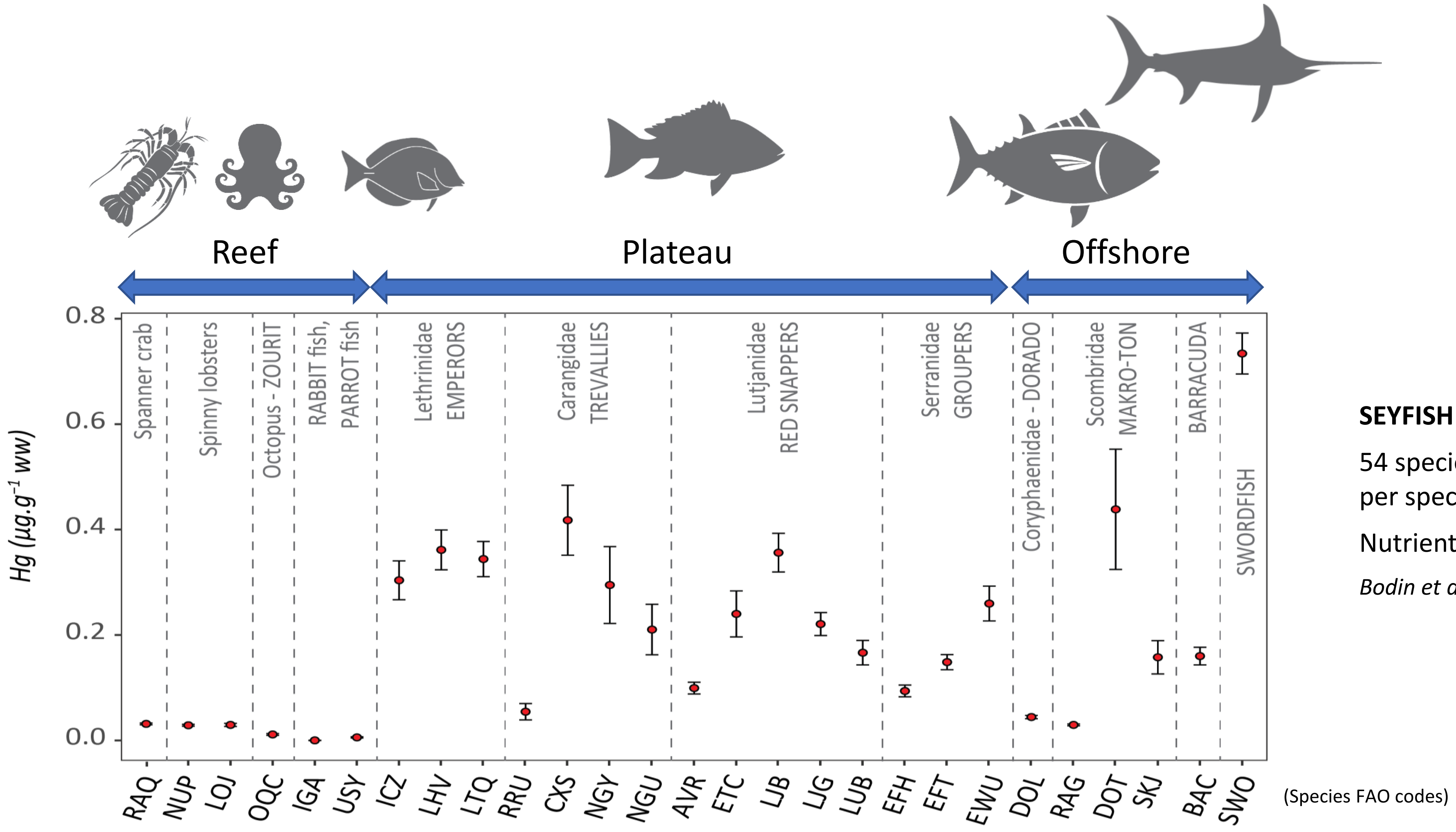
Pelagic Species



DHA 22:6ω3 | EPA 20:5ω3 | AA 20:4ω6



Data: Strain JJ



SEYFISH Project

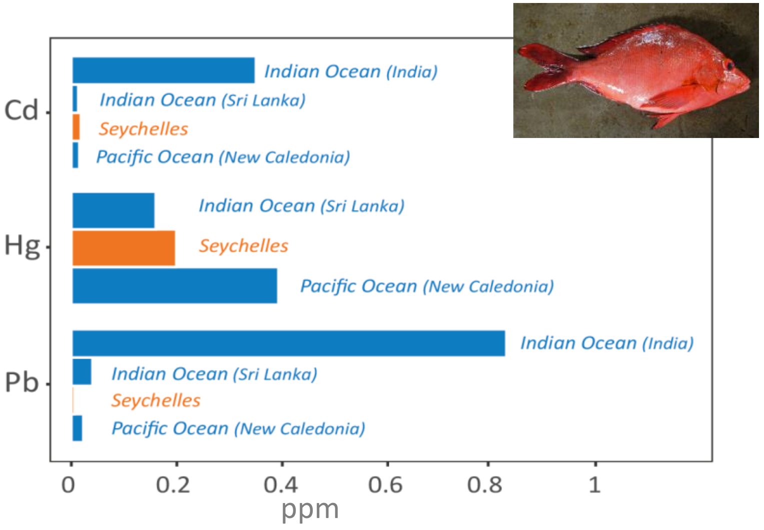
54 species (3-10 individuals per species)

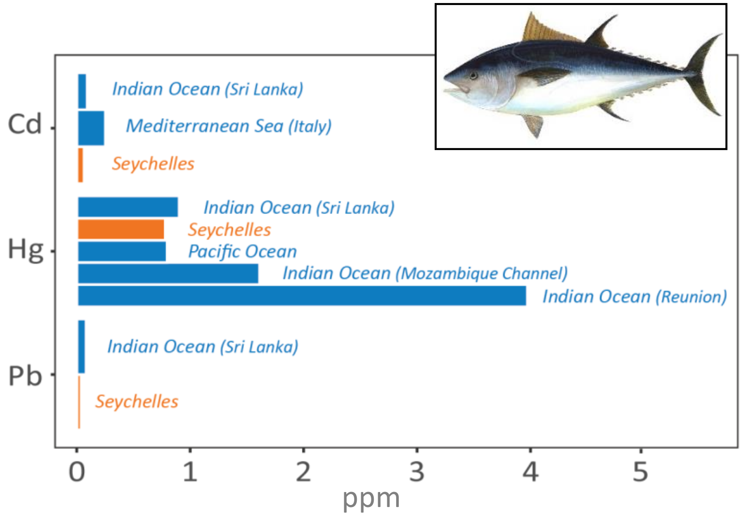
Nutrient and contaminant data

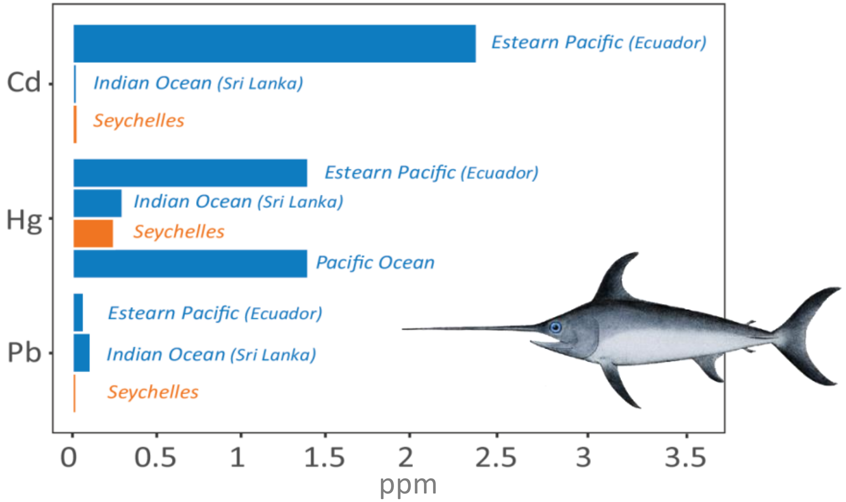
Bodin et al. submitted STOTEN

- Seychelles marine resources have total Hg levels below the recommended limits (eg, 1ppm for large pelagic and 0.05ppm for all other species). MeHg contributes to 70-90% of total Hg in marine resources
- This level is considered low and comparable to commercially available fish in developed countries.

How Seychelles fish compare to the rest of the globe

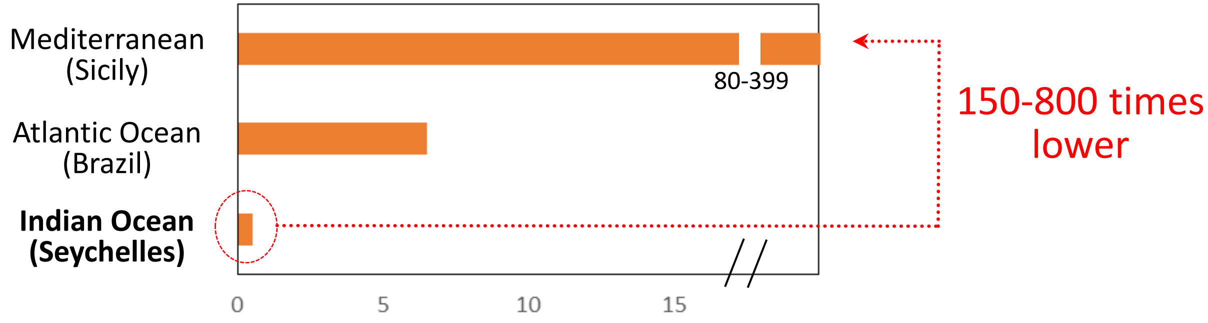






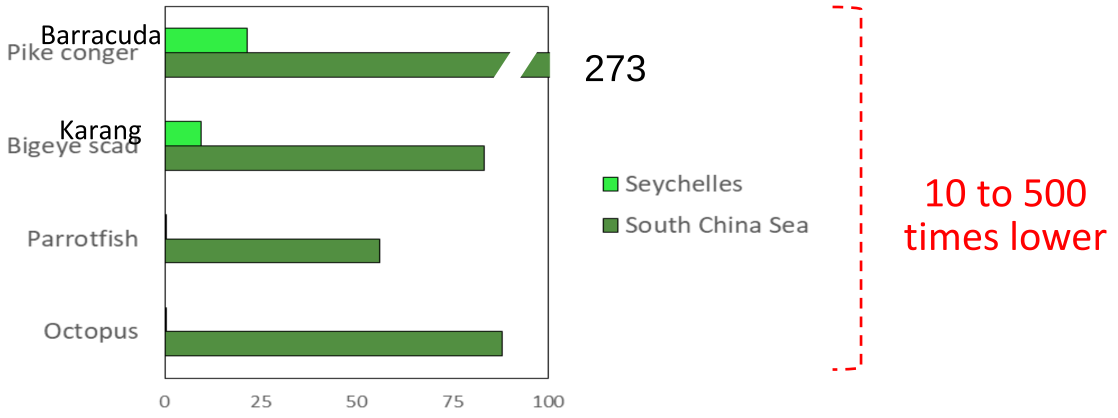
Bodin et al. submitted (SOTEN)

PCBs in Swordfish (ng g^{-1} ww)



Munschy et al. 2020a, 2020b

DDTs in tropical species (ng g^{-1} lw)

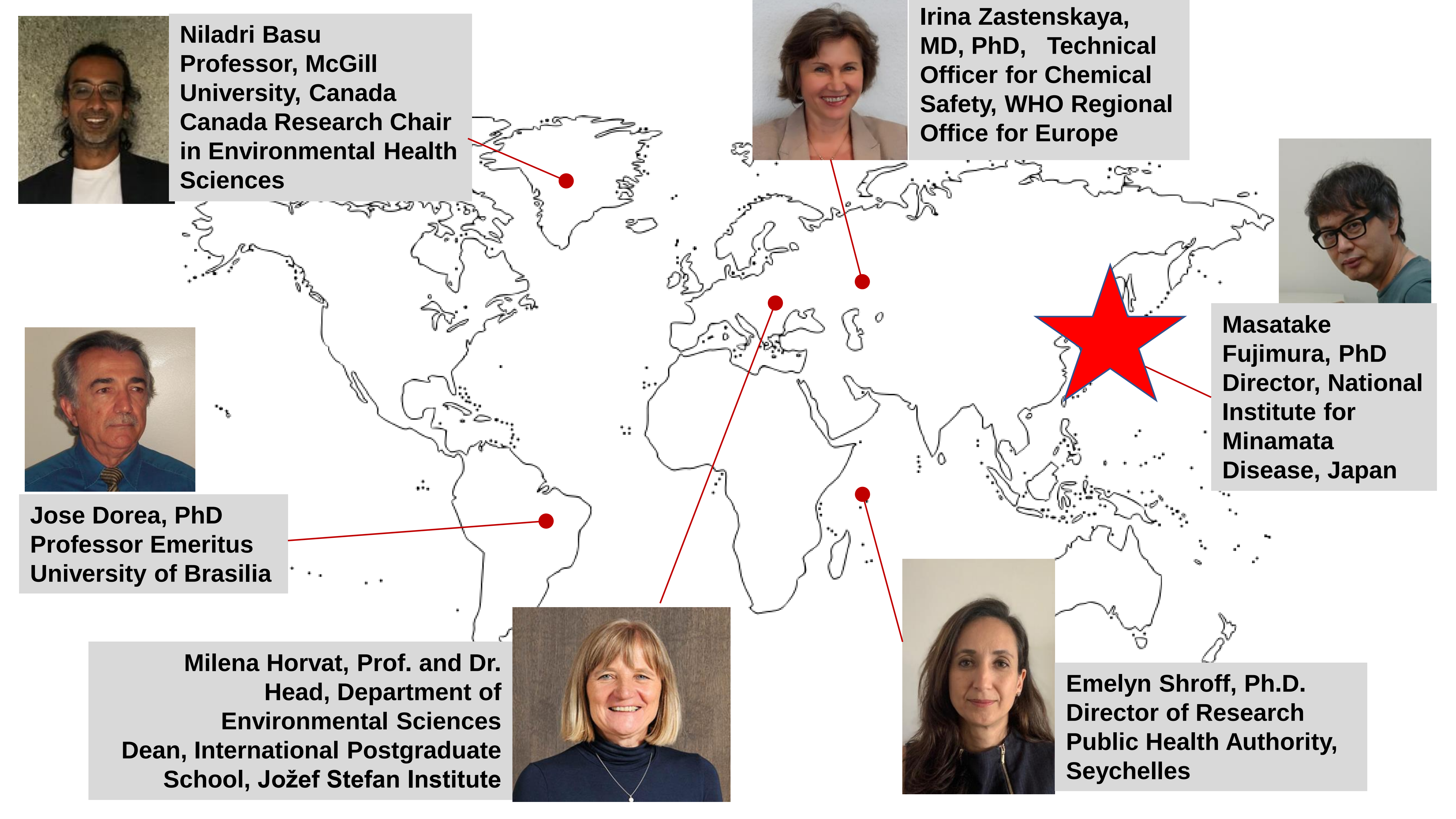


Munschy et al. In prep

Conclusions

- Fish is a natural source of protein for billions of people worldwide and contain important micro and macro nutrients important for growth and brain development
- There is no adverse effects seen in the Seychelles population over 30 years of study, but rather beneficial effects as seen in early years of life from prenatal fish consumption exposure
- Levels of MeHg measured in Seychelles fish is considered low
- PUFAs play a beneficial role, especial the high n3/n6 ratio in the Seychelles fish
- Covariates measured has similar outcomes and shows that the population is similar to other populations.

Need to understand the balance between protecting humans against the toxic effects of mercury, and at the same time promoting fish as a good source of micro and macro nutrients and for human development and health



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Asia region
-Background-

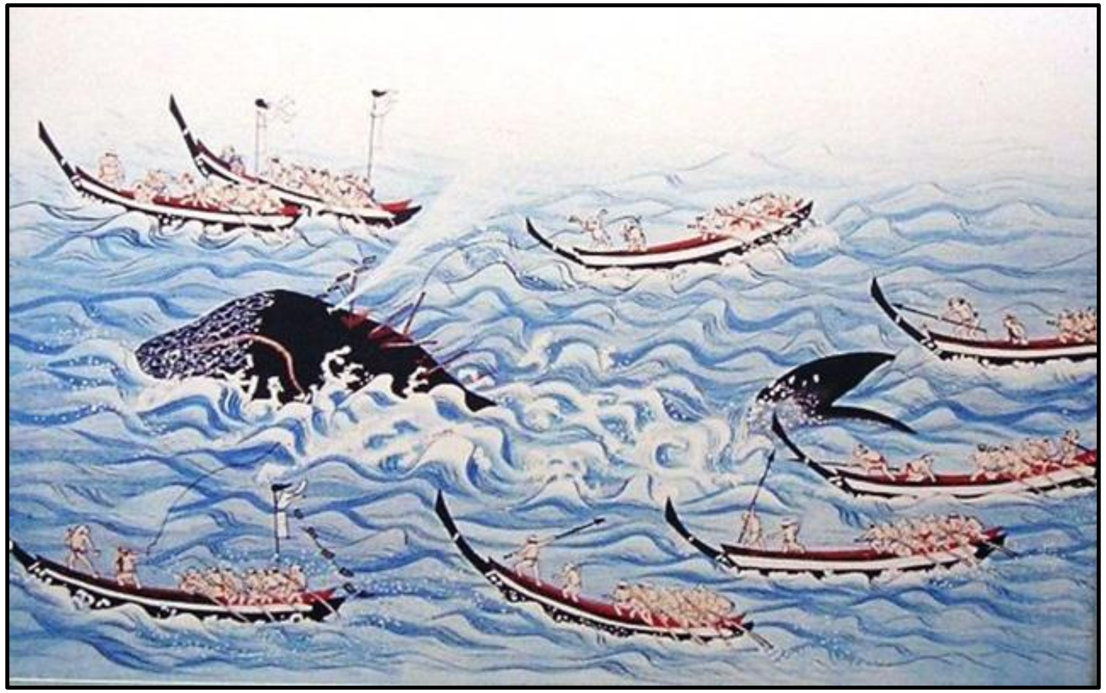
- Asians have higher seafood / mercury intakes than non-Asians (UNEP, 2019).
- Increasing per capita consumption of fish and shellfish is a global trend, but especially in Asia and Oceania, where fish-eating habits are naturally strong, there is a marked increase as living standards improve. In particular, growth is conspicuous mainly in emerging countries, such as about 9 times in China and about 4 times in Indonesia in the past half century (FAOSTAT, 2018).

Asia region

–Impact on whale food culture and neurological symptoms-

The Japanese have been eating whale meat and utilizing whalebones, blubber and oil for more than two thousand years.
Although the 1960's the supply of whale meat has gradually declined and accordingly consumption has been reduced, some whaling remained within the traditional areas where it still plays an important role as the basis of solidarity in the community, especially Taiji region.

Discussion about the pros and cons of whale food culture is another matter.

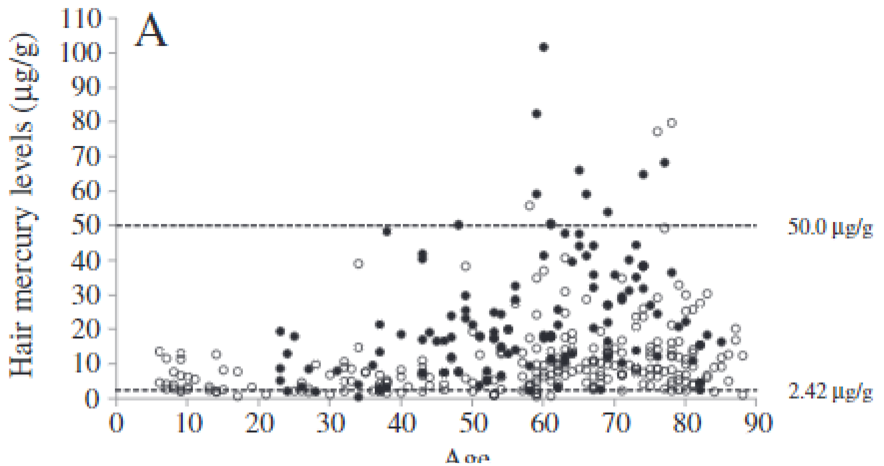


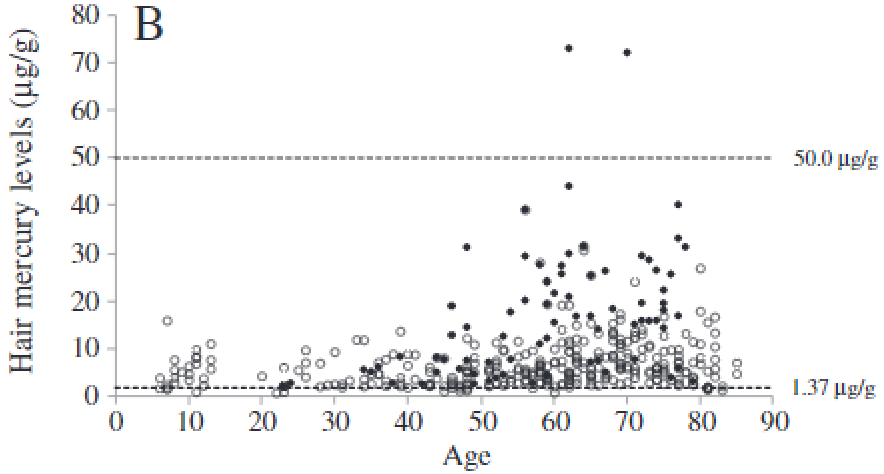
Whale culture (old painting)

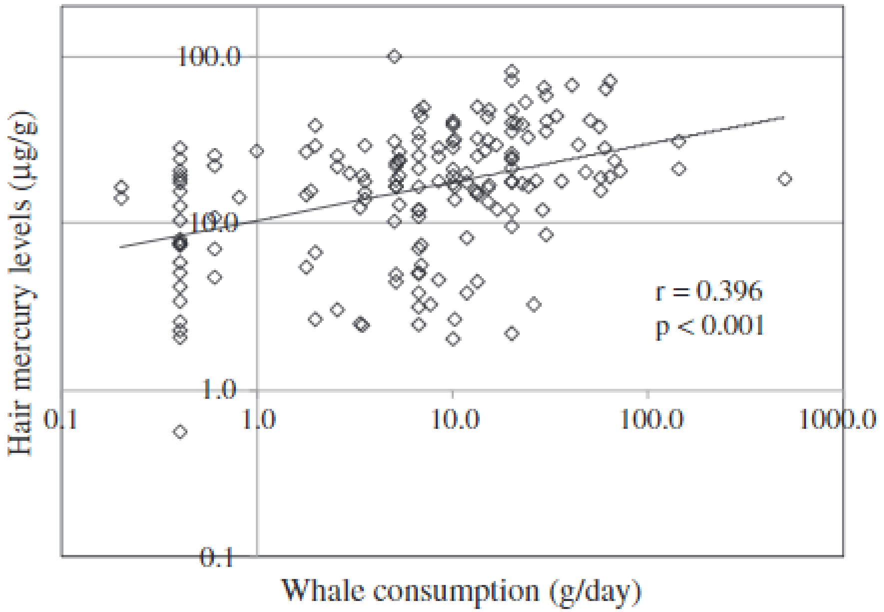
Whale food culture

Asia region
–Impact on whale food culture and neurological symptoms-

NIMD, to which I belong, conducted a survey on the relationship between mercury intake and neurological symptoms in whale-rich areas.







The subjects were 194 residents (117 males, 77 females; age 20-85 years) who resided in the coastal town of Taiji, the birthplace of traditional whaling in Japan.

The geometric mean of the hair mercury levels was 14.9 μg/g.

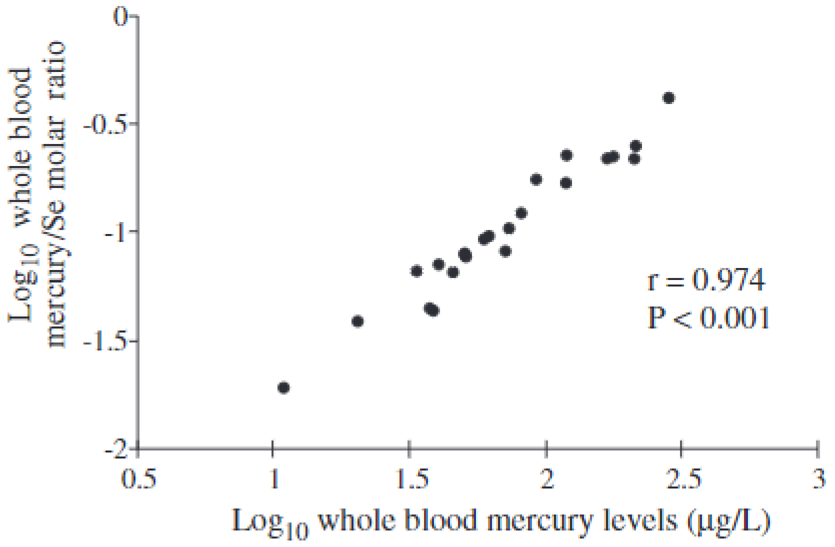
Twelve subjects revealed hair mercury levels >50 μg/g (NOAEL) set by WHO.

Hair mercury levels significantly correlated with daily whale meat intake.

Nakamura et al., Environ Int, 2014

Asia region
–Impact on whale food culture and neurological symptoms-

Detailed neurological examinations, audiometry, magnetic resonance imaging, and electromyography were performed to diagnose neurological defects.
Furthermore, whole blood mercury and selenium (Se) levels were measured in 23 subjects.



Summary of neurological findings of 12 subjects with hair mercury levels >50 μg/g.

No	Gender	Hair mercury (μg/g)	Wide-based gait	Sensorineural hearing loss	Cerebellar sign
1	M	50.4	(−)	(−)	(−)
2	M	50.6	Mild (+)	(−)	(−)
3	M	54.0	(−)	Left (+)	(−)
4	M	59.2	(+)	(+)	(−)
5	M	59.2	(−)	(−)	(−)
6	M	65.0	(−)	(−)	(−)
7	M	66.2	(−)	(+)	(−)
8	M	68.4	(−)	(+)	(−)
9	F	72.2	(−)	(−)	(−)
10	F	73.1	(−)	(−)	(−)
11	M	82.6	(−)	(−)	(−)
12	M	101.9	(−)	(−)	(−)

A significantly positive correlation between whole blood mercury and Se levels was observed and the whole blood mercury/Se molar ratios of all subjects were <1.
(It is thought that selenium compounds have an antagonistic effect on the toxicity of methylmercury)
Multivariate regression analysis demonstrated no significant correlations between hair mercury levels and neurological outcomes, whereas some of the findings significantly correlated with age.

These findings suggested that sufficient Se intake might be one of causes of the absence of adverse effects of MeHg exposure in this study.

Nakamura et al., Environ Int, 2014

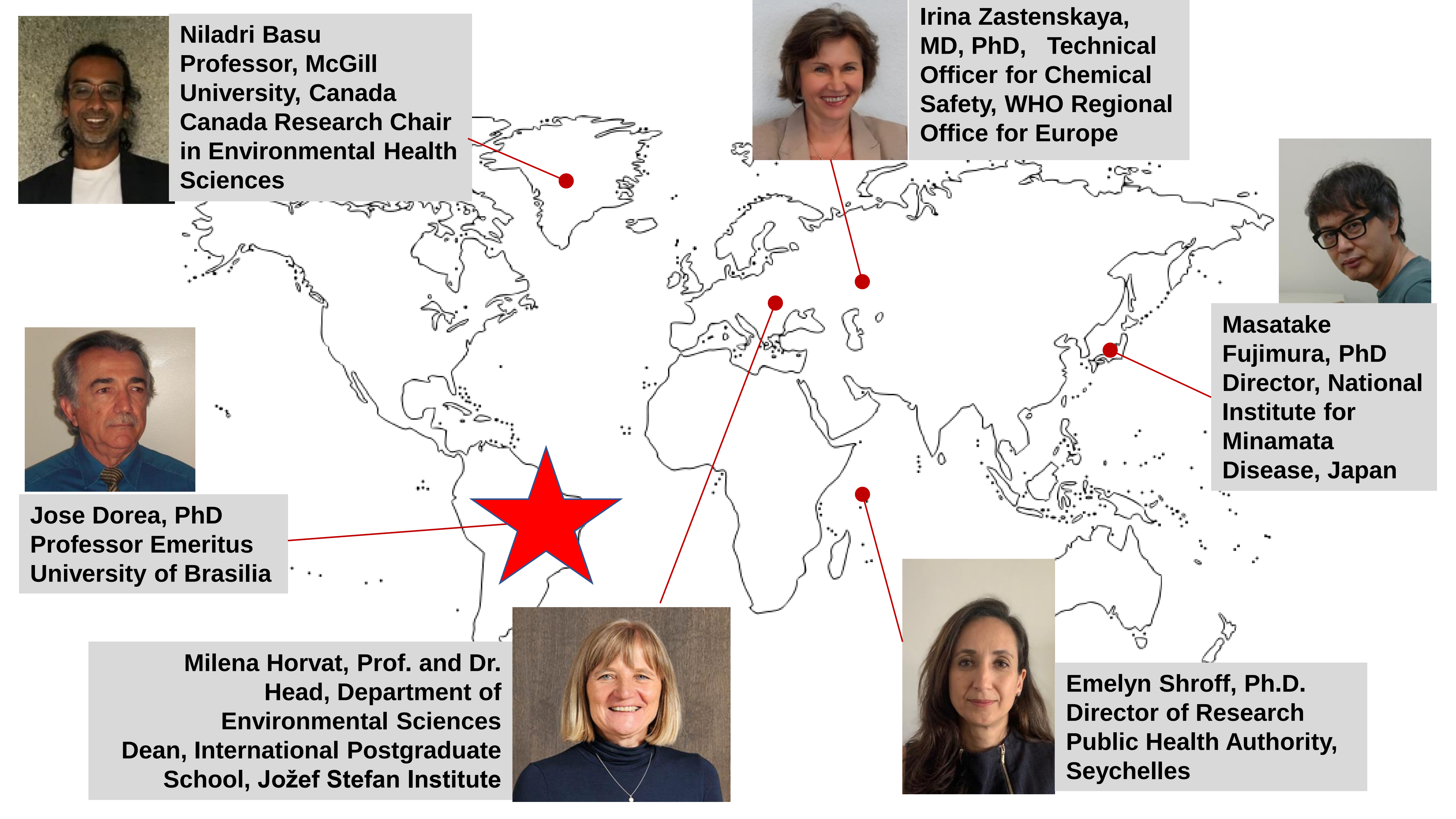
Asia region
–Whale food study and Amazon study-

Some reports have described possible MeHg toxicity in adults withhair mercury levels＜50μg/g (Kosatsky and Foran, 1996; Lebel et al.,1996, 1998).

These were reports of studies conducted on inhabitantsin the Amazonian Basin, which demonstrated that disorganized movements during an alternating movement task as well as decreased colordiscrimination capacity were observed with increasing total hair mercury levels (<50μg/g).

Nevertheless, in our study, neurological specialists did not detect impairment of skilled motor activities in the subjects with high hair mercury levels (>50μg/g).

Further study, including analysis of serum Se levels, will be needed to explain the difference between the results of Amazonian studies and our study.



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View from Brazil / Latin America

- Integrating Hg chemical-forms, exposure pathways, risks, benefits (associated with neurodevelopment), and modifiable factors frequently reported in low and mid-income countries (LMICs), with a focus on Brazil and Latin America

Chronologically organized summary of studies associating hair-Hg concentrations and rate of fish consum

References	Amazon River Basin	n	Hair [Hg], µg. g^{-1}; mean/[median]	Fish consumption mean g. day^{-1}/[meal frequency]
Riverine				
This study	Madeira River-LP	Women (22)	11.34	167
		Children (26)	6.07	97
This study	Madeira River-SST	Women (22)	7.97	117
		Children (54)	6.47	95
Oliveira et al. [20]	Madeira River	120	17.4	406
Passos et al. [32]	Tapajós River	72	17.9	151.1
Dórea et al. [27]	Negro River	31	[18.3]	170.5
Guimarães et al. [47]	Tartarugal River	30	28.0	200
Kehrig et al. [48]	Tocantins River	125	6.5	110
Amerindians				
Dórea et al. [49]	Tapajós River	249[a]	3.4[a]	30[a]
		47[b]	12.7[b]	110[b]
Frery et al. [34]	Maroni River	165	11.4 [4.2]	262*
Brabo et al. [50] and Santos et al. [51]	Tapajós River	324	15.7	[daily]
Cordier et al. [52]	Maroni River	96	11.7	[6.5 times/week]

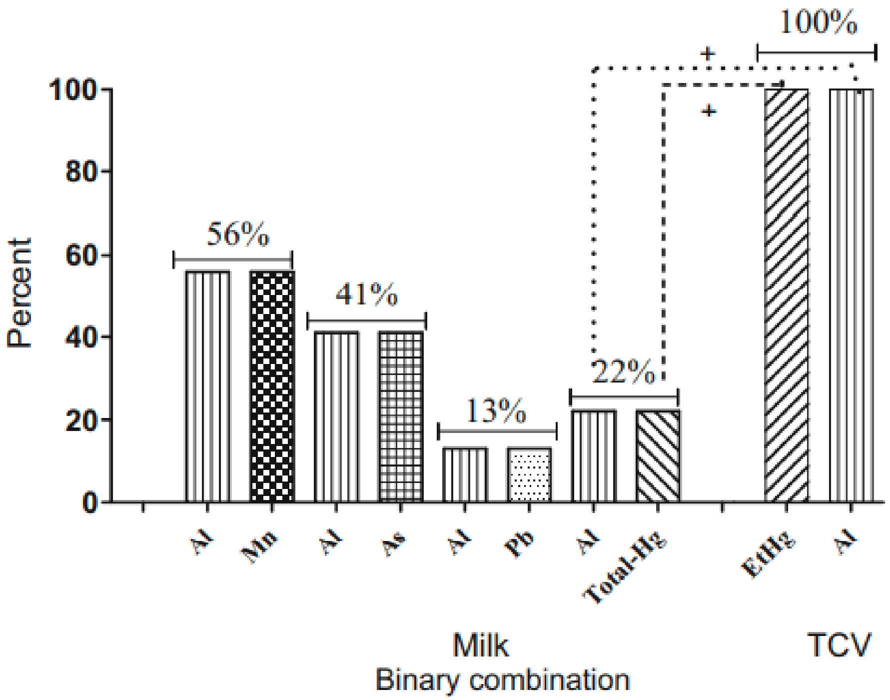
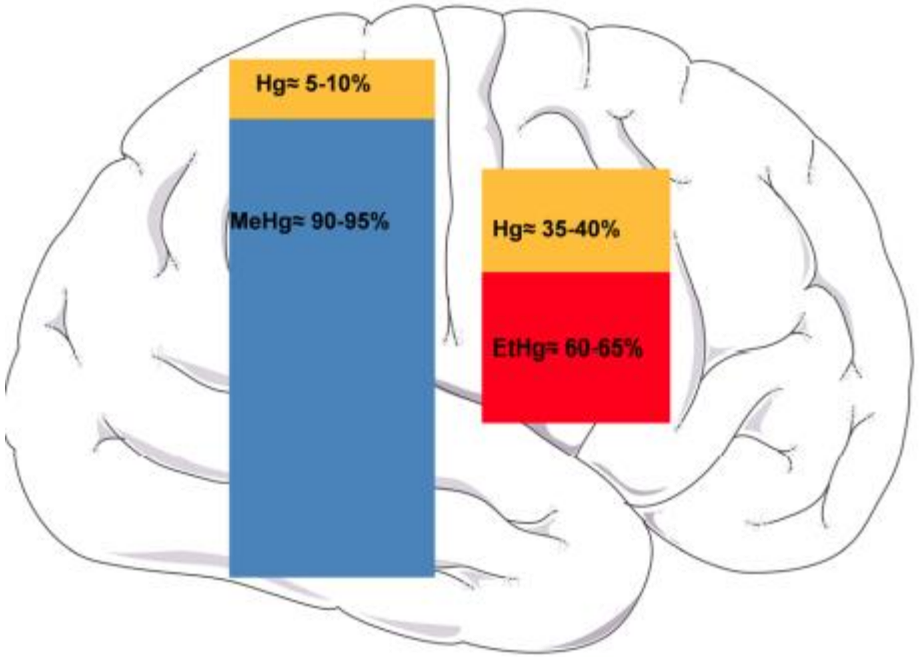
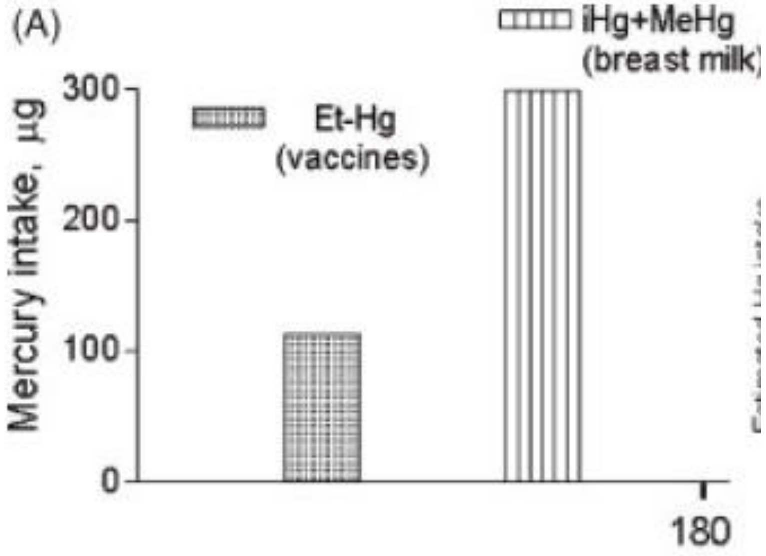


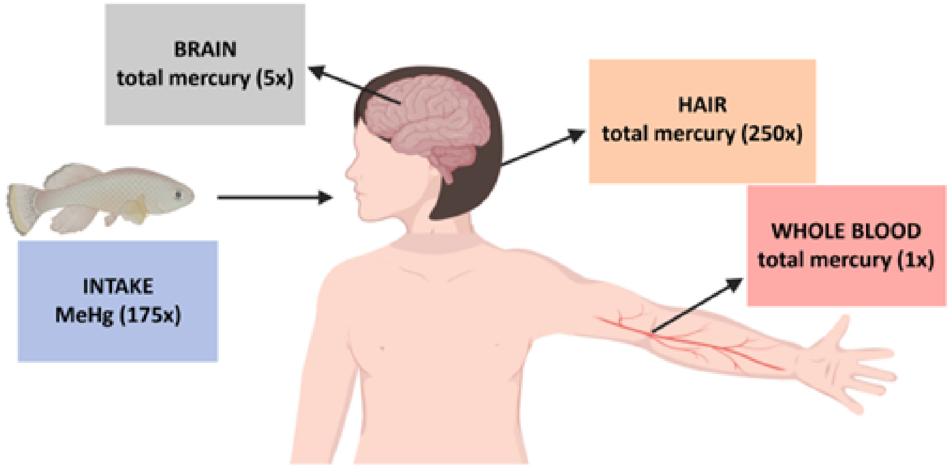
Fig. 2 Frequency of occurrence of binary combination of neurotoxic metals in human milk (matching samples with concentrations above limit of detection) and in thimerosal-containing vaccine (TCV; hepatitis B) taken at birth by donors' infants





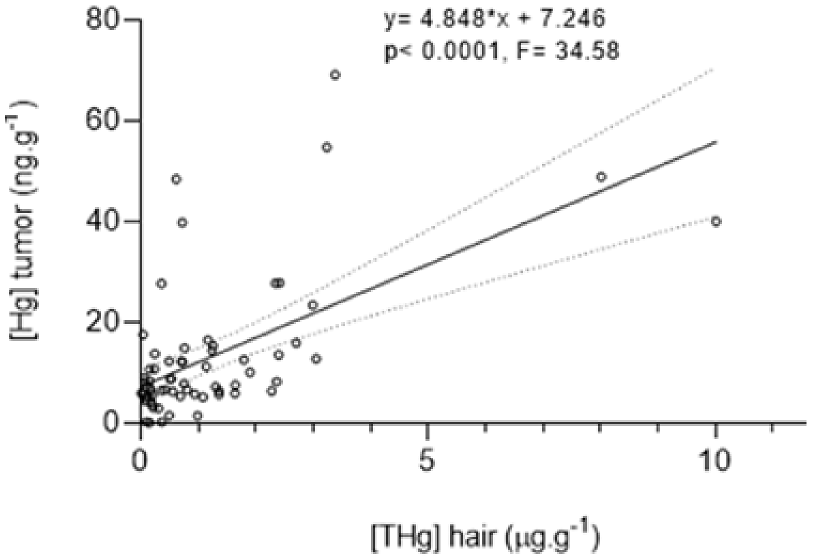
	Riverines	Porto Velho
Breast milk		
Total Hg ($ng\,g^{-1}$)	2.30 [0.12–6.48]	0.36 [0.09–3.74]

International Journal of Hygiene and Environmental Health 216 (2013) 682–689



	MeHg Intake		Total Mercury		
			Hair	Brain	Whole blood
	µg/Kg per week	µg per week[1]	µg/g or ppm	µg/g or ppm	µg/ml or ppm[2]
USEPA reference dose	0.7	42	1	0.02	0.004
WHO reference dose	1.6	98	2.3	0.046	0.0092
Ratio	**175**		**250**	**5**	**1**

The ratios of median THg concentrations among tissues were respectively 72 (hair:brain), 573 (hair:blood), and 6 (brain:blood).



Children

Grandjean et al. (1999)	7–12 y	*Cognitive, language and intellectual development:* Wechsler; Stanford-Binet; *Motor function:* Santa Ana test
Cordier et al. (2002)	9 m–6 y	*Cognitive, language and intellectual development:* Stanford-Binet; McCarthy *Motor function:* Leg Co-ordination, Finger tapping
Tavares et al. (2005)	3–7 y	*General development:* Lefèvre Evolutional Neurological Test
Marques et al. (2007)	6 m	*General development:* GDS
Marques et al. (2008)	6 m	*General development:* GDS
Fonseca et al. (2008)	7–16 y	*Cognitive, language and intellectual development:* WISC-III; *Audition, visual and visual-motor development:* Figure drawing.
Marques et al. (2009)	; 36; 60 m	*General development:* GDS
Chevrier et al. (2009)	7–12 y 5–12 y	*Cognitive, language and intellectual development:* Stanford-Binet
Marques et al. (2010)	6 m	*General development:* GDS
Marques et al. (2011)	0–5 y	*General development:* GDS
Marques et al. (2012)	0–5 y	*General development:* GDS
Dórea et al. (2014)	12–24 m	*General development:* GDS
Marques et al. (2014)	6; 24 m	*Neurodevelopmental disorders and other health outcomes:* BSID-II
Marques et al. (2015)	6; 24 m	*Neurodevelopmental disorders and other health outcomes* BSID-II
Marques et al. (2016)	6; 24 m	*Neurodevelopmental deficits:* BSID-II
Marques et al. (2016)	6; 24 m	*Neurodevelopmental deficits:* BSID-II

Adults

Santos et al. (1995)	Environmental and occupational	—	
Lebel et al. (1996)	Environmental	Visual testing	SS
Santos et al. (1999)	Environmental	—	
Lebel et al. (1998)	Environmental	Santa Ana test, grip strength, tests of visual acuity, Branches Alternate Movement Task	SS
Dolbec et al. (2000)	Environmental	Santa Ana, Grooved Pegboard, Finger-tapping, Strength tests (Grip strength and Pinch strength)	SS
Harada et al. (2001)	Environmental	Neurological test	SS
Silva et al. (2004)	Environmental and occupational	anti-nuclear autoanti-bodies (ANA): anti-nucleolar autoanti-bodies (ANoA)	
Silveira et al. (2004)	Environmental and occupational	Visual functions assessment	SS
Alves et al. (2006)	Environmental	Serum antinuclear anti-bodies (ANA)	
Rodrigues et al. (2007)	Environmental and occupational	Visual functions assessment	SS
Gardner et al. (2010)	Occupational	anti-nuclear autoanti-bodies (ANA); anti-nucleolar autoanti-bodies (ANoA)	
Lemire et al. (2010)	Environmental	Age-related cataracts	
Lemire et al. (2011)	Environmental	Motor functions	SS
Fillion et al. (2011a)	Environmental	Lanthony D-15 desaturated test; Santa Ana test, Grip Strength	SS
Fillion et al. (2011b)	Environmental	Visual functions assessment	SS
Nyland et al. (2011)	Environmental	Anti-nuclear autoanti-bodies (ANA); anti-nucleolar autoanti-bodies (ANoA)	
Fillion et al. (2013)	Environmental	Near visual contrast sensitivity and colour vision	SS
Khoury et al. (2013)	Environmental	Neurological evaluation	SS
Hoshino et al. (2015)	Environmental	Otolaryngologicevaluation; acoustic reflexes; audiometry	

Chemical form	Pathway	Prevalence	Mode	Stage of exposure	Combined stressors	Associated benefits	Risks	Biomarker	Modifiable Hg risks
EtHg	TCV	High in LMICs	Non-oral (i.m.)	MPr,NB, IF, CH	Al adjuvants	Life-saving prevention of diseases	Possible neurodevelopmental delays associated with EtHg	Bl>Ur	Make Thimerosal-free vaccines to LMICs.

EtHg: ethyl-Hg; MPr: Mother-Pregnancy; M-Lc: Mother-Lactation; IF: infant; CH: child; LMICs: low and mid-income countries; Bl: blood; Ur: urine.

Chemical form	Pathway	Prevalence	Mode	Stage of exposure	Combined stressors	Associated benefits	Risks	Biomarker	Modifiable Hg risks
MeHg	Fish	High in traditional living	Oral	MPr, MLc, CH	Dependent on maternal diet/lifestyle	Essential nutrients	Possible neurodevelopmental delays associated with MeHg	H>N>Bl	**Advisories for commercial fish consumers.**
MeHg	Human milk	High in traditional living	Oral	Infancy	Dependent on maternal diet/lifestyle	Essential nutrients and functional factors	No evidence of detrimental effects due to mode of feeding	H>N>Bl	**Intervention only in clinical poisoning cases.**
MeHg	**Rice**	**High in Asian countries**	**Oral**	**MPr, MLc, CH**	**Dependent on maternal diet/lifestyle**	**Essential nutrients**	**Possible neurodevelopmental delays associated with MeHg**	**H>N>Bl**	**Environmental policies to abate Hg pollution.**

MeHg: methyl-Hg; MPr: Mother-Pregnancy; M-Lc: Mother-Lactation; IF: infant; CH: child; SSA: Sub-Saharan Africa; LMICs: low and mid-income countries; H: hair; N: nail; Bl: blood.

Chemical form	Pathway	Prevalence	Mode	Stage of exposure	Combined stressors	Associated benefits	Risks	Biomarker	Modifiable Hg risks
InHg/MeMg	Geophagy practices (soil sticks)	SSA	Ingestion	Culture	Dependent on maternal life style	Lifestyle	Neurodevelopment	Bl>Ur	**Proper health services**
InHg (cinnabar) MeMg	**Traditional medicines**	**ASIA**	**Ingestion**	**Malasies / Illfeeling**	**Dependent on maternal life style**	**Cure/relief of symptoms**	**Not studied**	**Bl>Ur**	**Proper medical services**

MeHg: methyl-Hg; InHg: inorganic Hg; MPr: Mother-Pregnancy; M-Lc: Mother-Lactation; IF: infant; CH: child; SSA: Sub-Saharan Africa; Bl: blood; Ur: urine.

Chemical form	Pathway	Prevalence	Mode	Stage of exposure	Combined stressors	Associated benefits	Risks	Biomarker	Modifiable Hg risks
InHg	Cassava (in contaminated soil)	High in SSA	Ingestion	Staple food	Dependent on maternal life style	Nutrition	Not studied	Bl>Ur	**Proper nutritional alternatives**
InHg	Dental worker	High in LMICs	Inhalation	MPr, MLc	Dependent on maternal diet/lifestyle	Increase in family income	No neurodevelopmental delays in sons of dental workers (Vähäsarja et al, 2016).	Bl>Ur	**Occupationally protected environment.**
InHg	Teeth restauration	High in LMICs	Ingestion	MPr, MLc	Dependent on maternal diet/lifestyle	Dental heatlh	No neurodevelopmental delays due to prenatal dental amalgam exposure.	Bl>Ur	**Alternative tooth filling materials.**
InHg	ASGM worker	LMICs	Inhalation	MPr, MLc	Dependent on maternal diet/lifestyle	Increase in family income	Neurodevelopmental delays.	Bl>Ur	**Public health policies to protect pregnant and lactating mothers**
InHg	ASGM worker	LMICs	Inhalation	Child labor	Dependent on the metal mined	Increase in family income	Neurodevelopmental delays.	Bl>Ur	**Enforce policies to protect children from exploitative child labor.**
InHg	e-waste worker	LMICs	Inhalation	MPr, MLc	Other metals and maternal diet/lifestyle	Increase in family income	Neurodevelopmental delays.	Bl>Ur	**Public health policies to protect pregnant and lactating mothers**
InHg	e-waste worker	LMICs	Inhalation	Child labor	Other metals	Increase in family income	Neurodevelopmental delays.	Bl>Ur	**Enforce policies to protect children from exploitative child labor.**
InHg	Skin bleachers	More in SSA	Dermal absorption	MPr, MLc	Dependent on maternal life style	Lifestyle/self esteem	Not studied	Bl>Ur	**Education and optional products development**
InHg (metalic)	Religious ´ractices (Santeria)	Carabbean	Inhalation	Ritual practices	Dependent on maternal life style	Cultural behavior	Not studied	Bl>Ur	**Medical treatment**
InHg (fumes)	**Volcanic activity**	**Volcanic areas**	**Inhalation**	**MPr, MLc, CH**	**Dependent on maternal life style**	**Natural Environment**	**Not studied**	**Bl>Ur**	**Challenging**

MeHg: methyl-Hg; InHg: inorganic Hg; MPr: Mother-Pregnancy; M-Lc: Mother-Lactation; IF: infant; CH: child; SSA: Sub-Saharan Africa; LMICs: low and mid-income countries; Bl: blood; Ur: urine.

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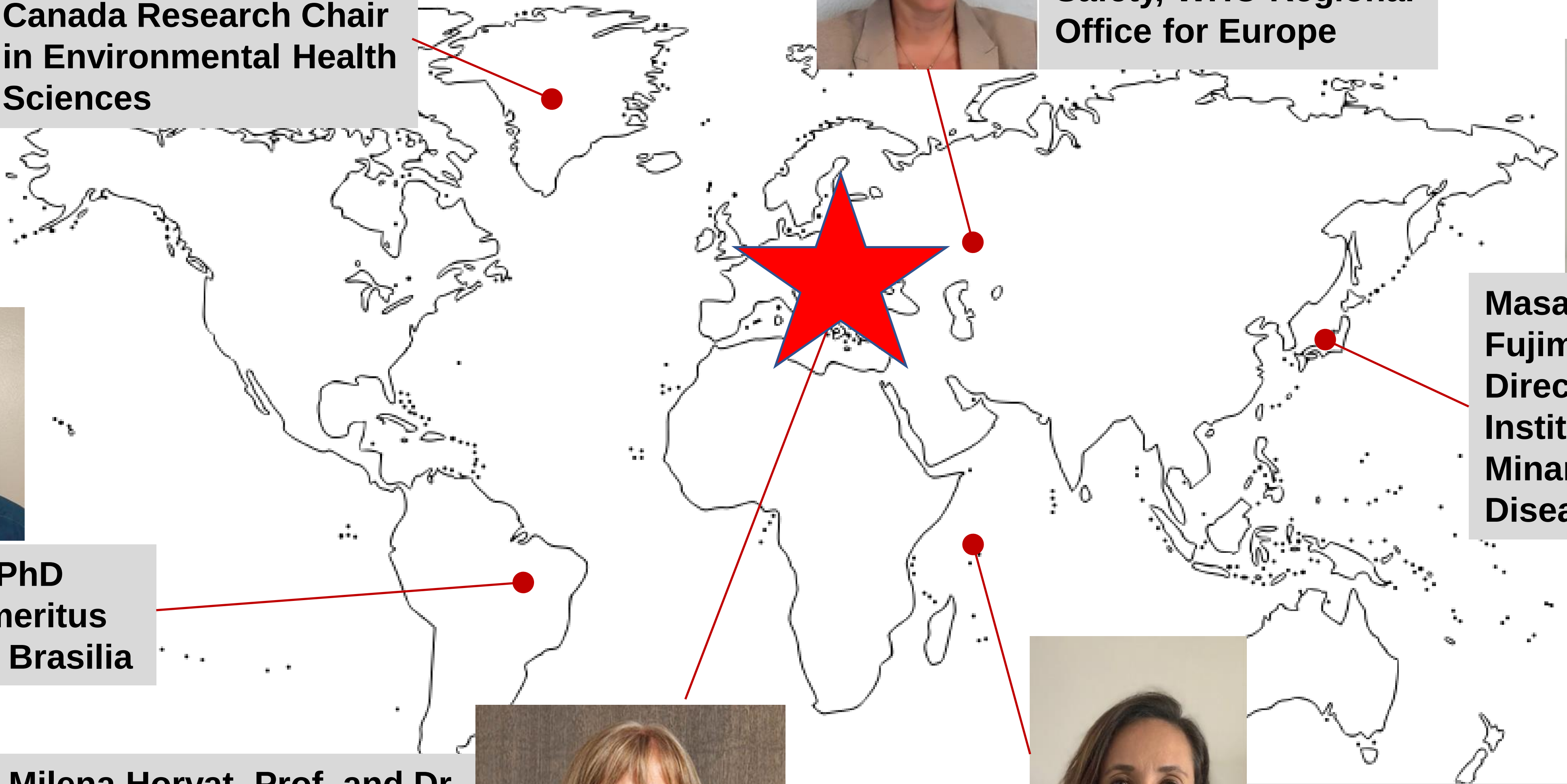
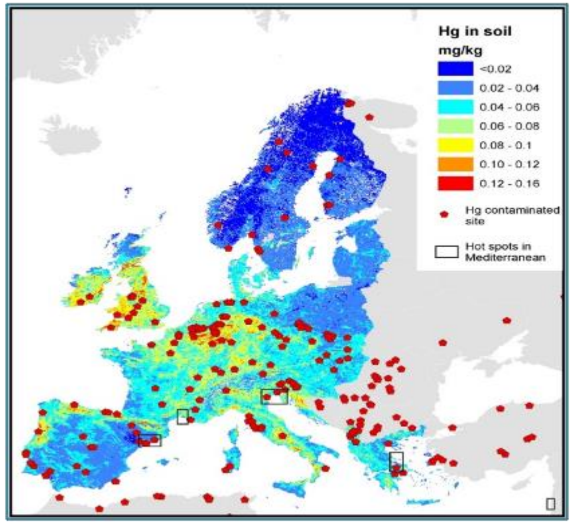


European policies

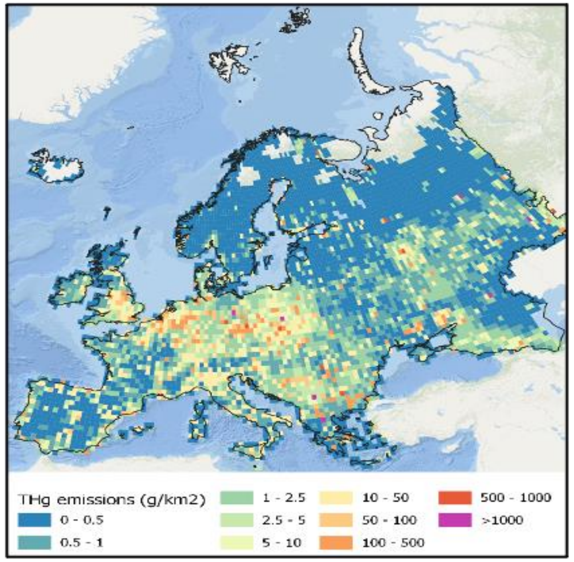
- Community strategy concerning mercury, 2005
- Food safety:
  - EFSA European Food Safety Administration
- Chemicals:
  - Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
- Environment
  - Surface waters, groundwater, emissions and releases, etc…
- Consumer products
- Occupational Health
- Global policies - Minamata Convention
- ……

Data availability – Hg sources

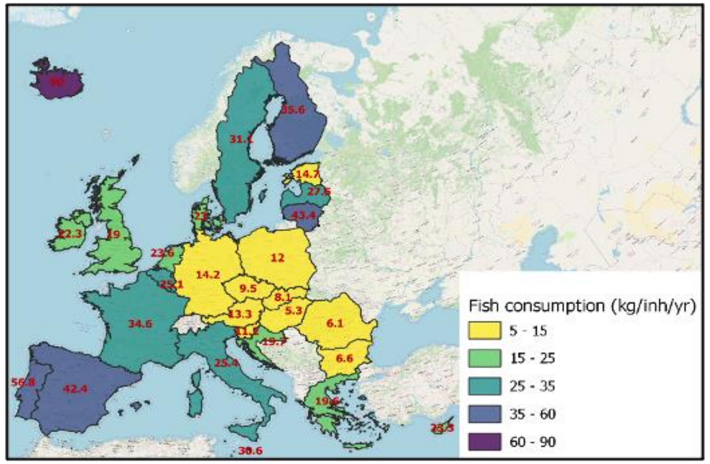
Hg in soils and contam. sites[1]



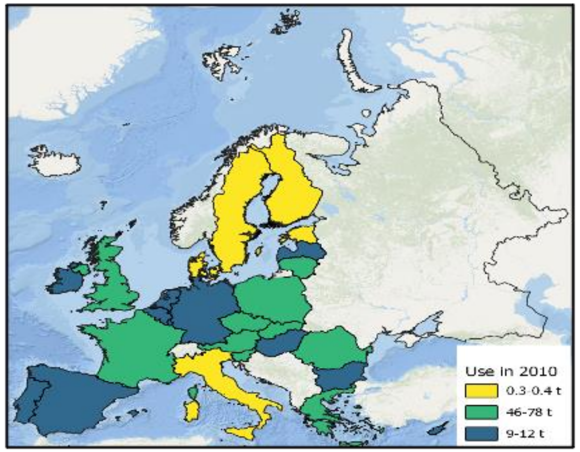
THg emissions[2]



Fish consumption[4]



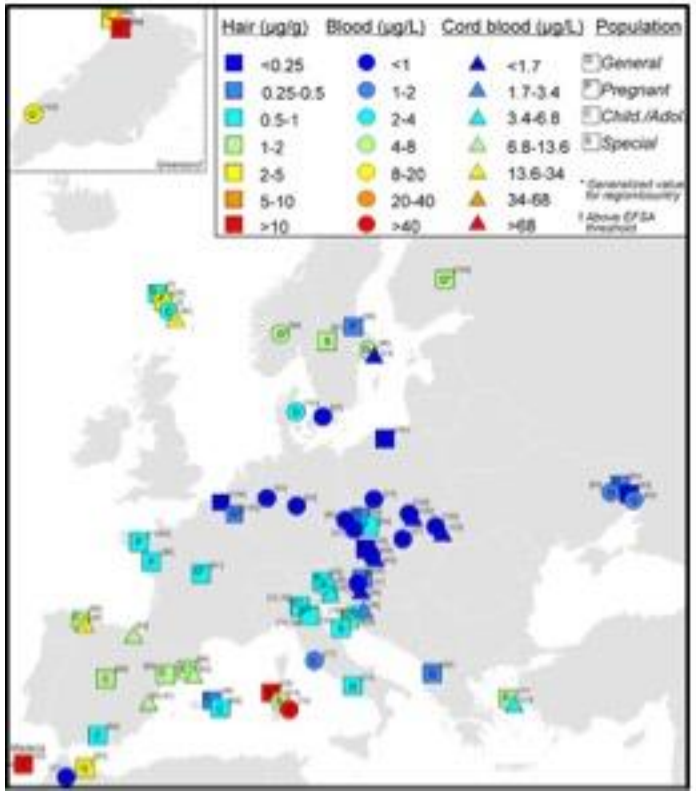
Use of dental amalgams[3]

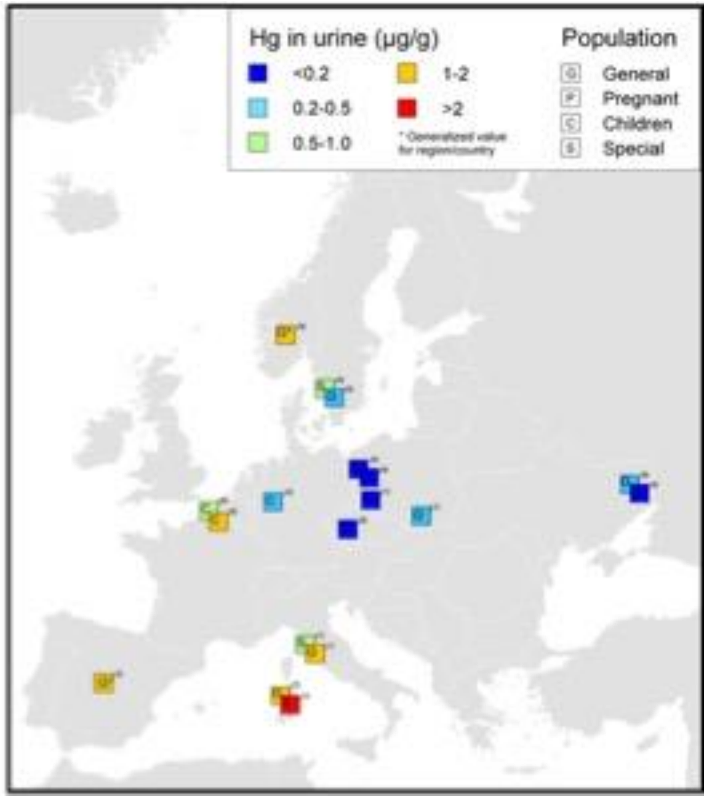


[1]Kocman et al. (2013), Lado et al. (2008)
[2]Steenhuisen & Wilson, 2015
[3]SWD/2016/017 final - 2016/023 (COD) Commission Staff Working Document Ratification and Implementation by the EU of the Minamata Convention
[4]Eumofa, The EU fish market, 2019 edition

Data availability: Hg levels in biomarkers

2000 - 2013



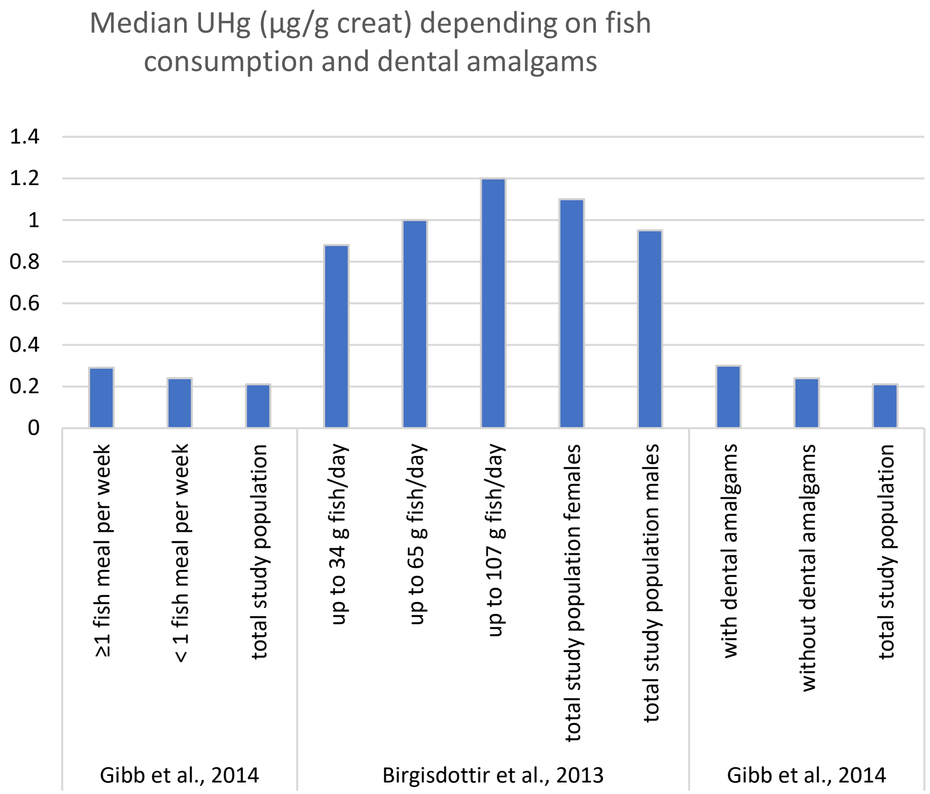


- Extracted information: - location, subgroup of the population (children /pregnant women /exposed population / general population), biomarkers of exposure (Hg in **cord blood, blood, urine and hair**), dose of exposure and different outcome measures
- ~50 studies included (12000 people from 21 countries were involved

Miklavčič - Višnjevec et al, 2014 and references therein

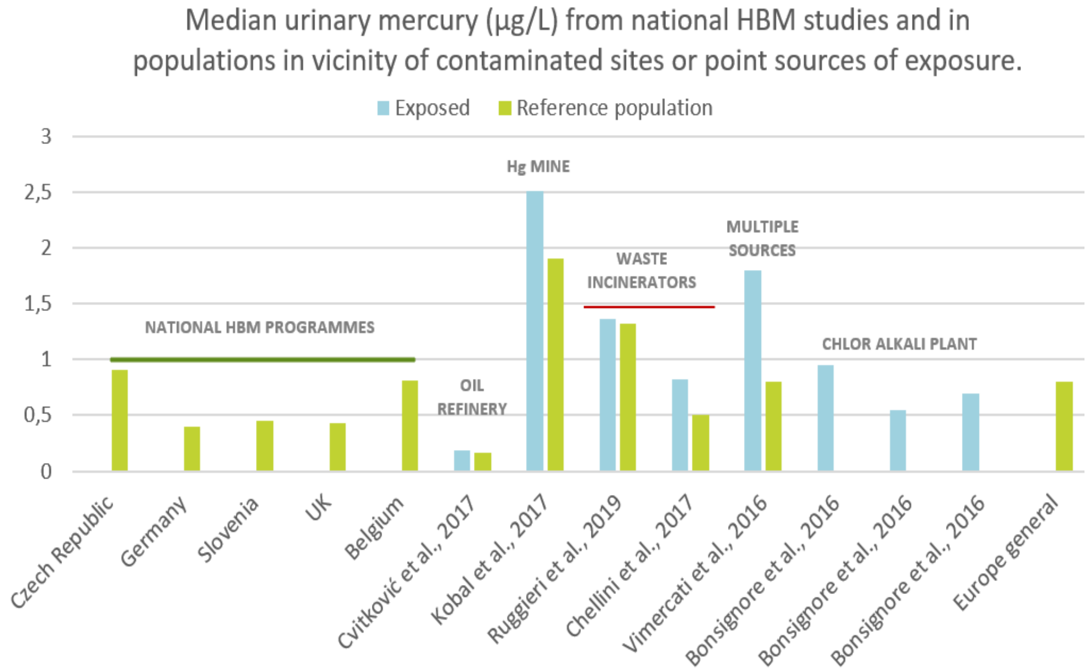
Data availability: Hg levels in urine

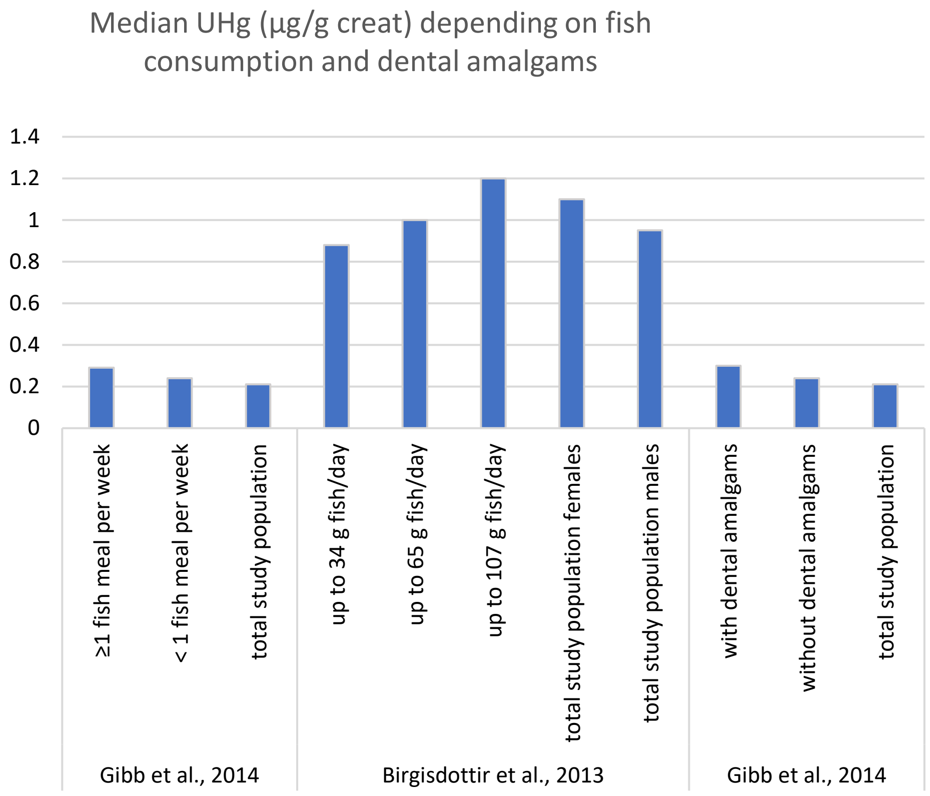
2013 -



Data availability: Hg levels in urine

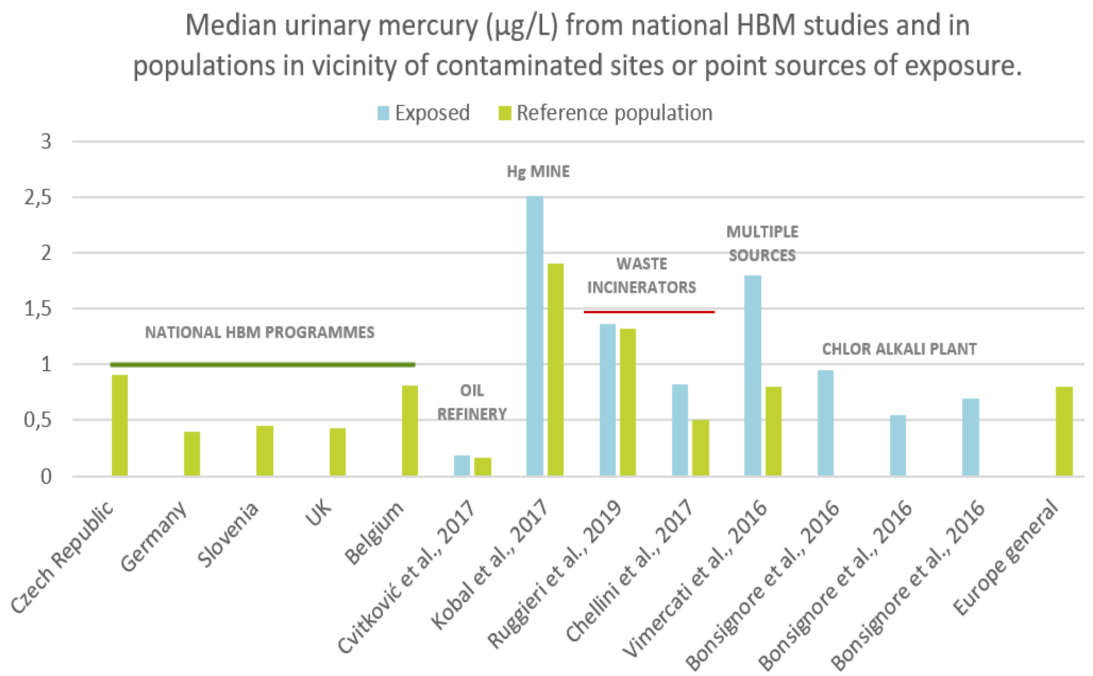
2013 -

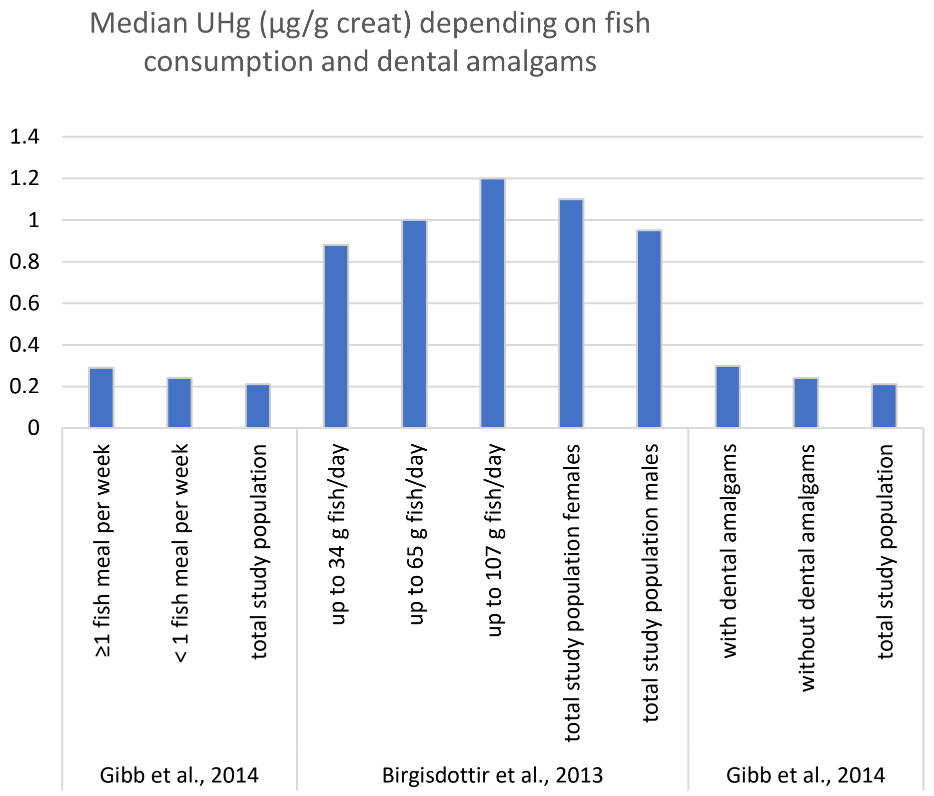


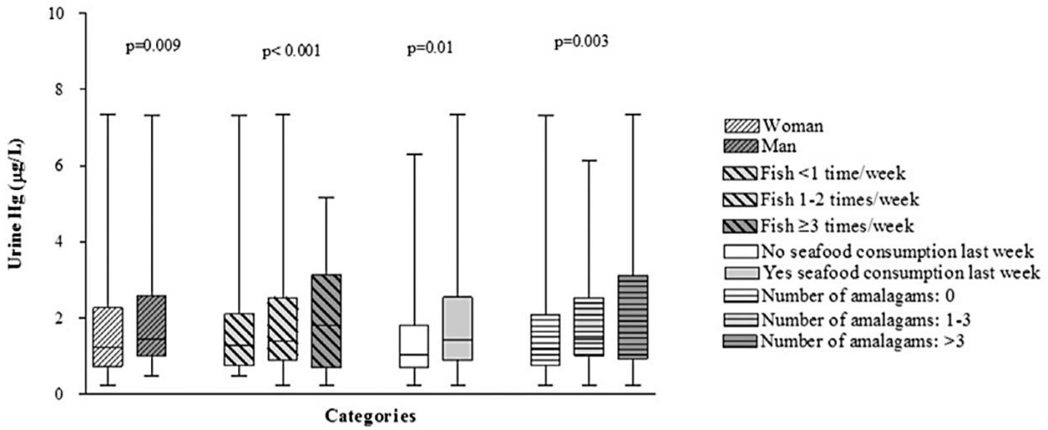


Data availability: Hg levels in urine

2013 -







Urinary Hg and determinant variables for adults living near waste incinerator (Bocca et al., 2016)

Research and development in Europe

- National programmes:
  - Human biomonitoring: reference values, spatial and temporal trends
  - epidemiological studies, etc ..
- EU Framework programmes
  - Environmental and health related (several projects funded for Hg research)

Consortium partners

Project coordination:
HBM4EU is coordinated by the German Environment Agency, Section II 1.2 Toxicology, Health Related Environmental Monitoring
Email: hbm4eu@uba.de

VITO is the Co-coordinator, Email: hbm4eu@vito.be

The first list of HBM4EU priority substances was identified in 2016 and includes:

- Aniline family
- Bisphenols
- Cadmium and chromium VI
- Chemical mixtures
- Emerging substances
- Flame retardants
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Per-/poly-fluorinated compounds
- Phthalates and Hexamoll® DINCH

A second round of prioritisation was conducted from 2017 to 2018. The second list of HBM4EU priority substances includes:

- Acrylamide
- Aprotic solvents
- Arsenic
- Diisocyanates
- Lead
- Mercury
- Mycotoxins
- Pesticides
- Benzophenones

HBM4EU policy related questions for mercury

1. How effective are policy actions **to reduce human exposure** to mercury in Europe?
2. How can harmonised, validated and comparable information be collected and transferred to support and evaluate current policies?
3. What biomonitoring and exposure data on mercury (and its species), relevant to the European population, are currently available and what new data are needed to address policy-related questions?
4. What is the geographic spread of the current exposure and how does it relate to different exposure sources (environmental; contaminated sites; dental amalgams; dietary, including different species of sea-food)? Ideally, this should capture the exposure of highly exposed populations (e.g. high seafood consumers with distinction of populations consuming predator fish from those with low/no consumption of such fish, such as Southern & Northern Europeans, European arctic populations), but also of low-exposure populations for comparison.
5. Which populations remain vulnerable to health impacts from mercury exposure and how can they be protected?
6. How can the public be informed and how can public awareness and education be raised regarding the effects of mercury on health and the environment and about management options? Related to this, how can HBM4EU results support policy decisions at EFSA and ECHA?
7. At what level of exposure to different mercury species and to total mercury are health effects likely to occur?
8. How does exposure relate to the manifestation of adverse health effects?
9. What are possible health effects resulting from chronic low exposure to mercury and its organic compounds (such as from food consumption and dental amalgams)?
10. What factors make people more susceptible to the development of health effects due to mercury exposure?

Adopted from: A. Katsounouri et al., HBM4EU Hg scoping document,
https://www.hbm4eu.eu/wp-content/uploads/2019/03/HBM4EU_D4.9_Scoping_Documents_HBM4EU_priority_substances_v1.0-Mercury.pdf

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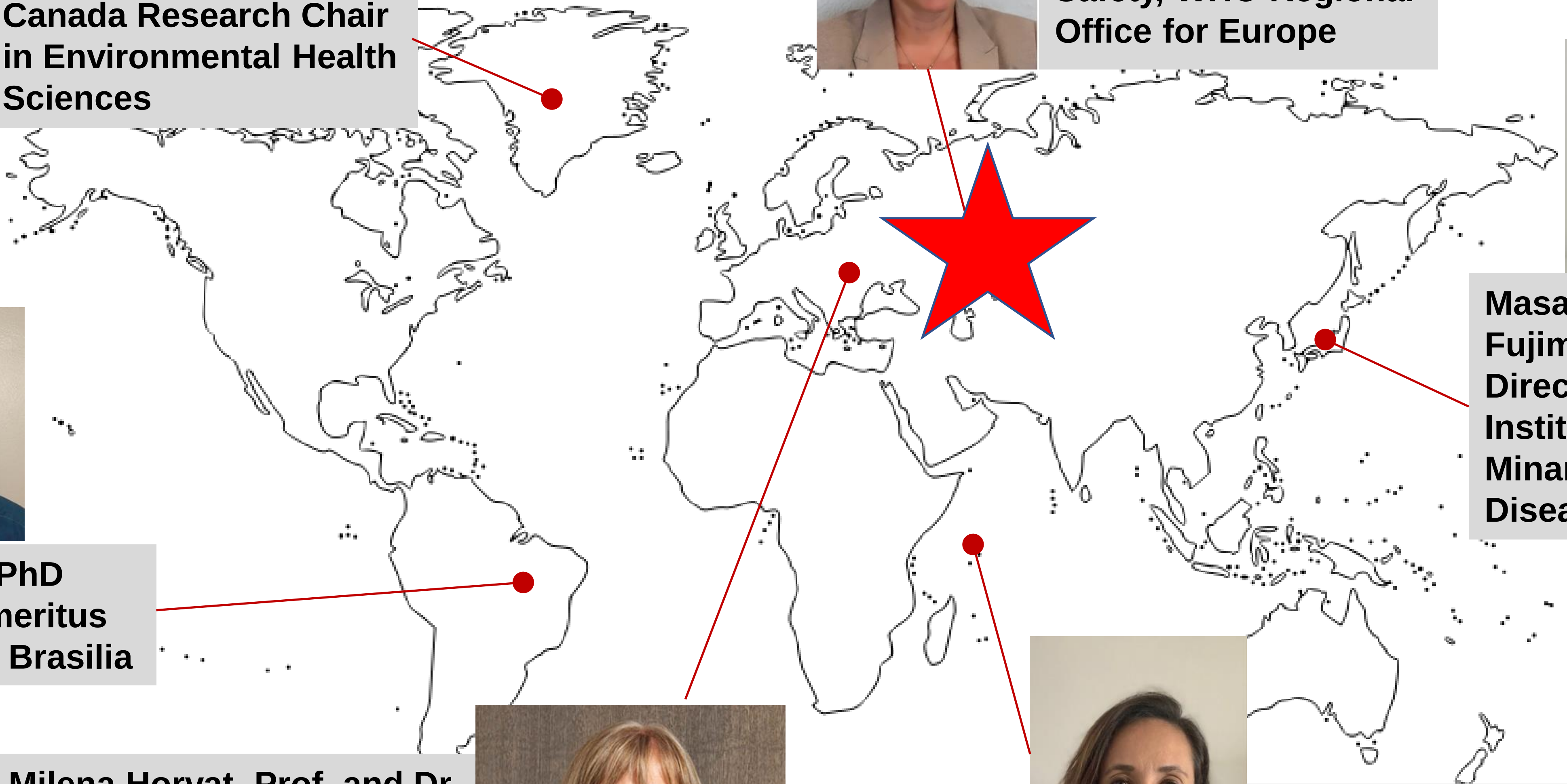

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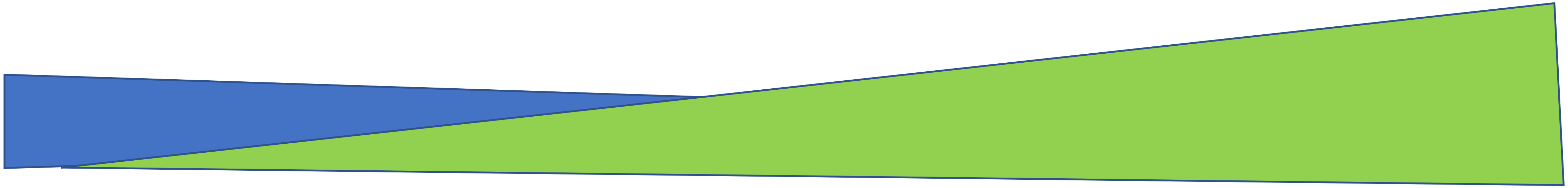
Exposure and health effects – knowledge accumulation

1950-1980	1980 - 2000	2000 - 2010	2010 - ….
Hazard assessment	Exposure – effect (quantitative assessment)	Shift of geographical and exposure focus	
Acute and massive poisonings	Lower dose – cohort studies	Focus on different sources of exposure (e.g. ASGM)	Complex planning of epidemiological studies to reveal mercury effects
Clinical symptoms	"Sub-clinical" effects (neurodevelopment)	Wider use of HBM	Harmonization of approaches (global level)
Occupational exposure, Minamata, Iraq	Seychelles Faroes	Asia Pacific, Africa, Latin America	
		ASGM, waste management, cosmetics	
		Child labour, community impacts	



Children – the vulnerable population group

Children

+ sensitivity

- Adults

Prenatal exposure

Breast milk

Occupational (controlled)

ASGM, waste management

Dental Amalgam (occupational, community)

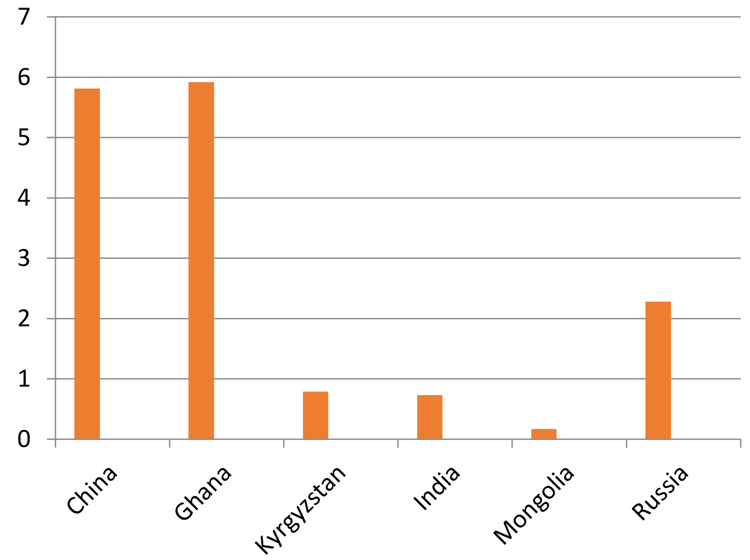
Skin-lightening cosmetic???

FOOD (the main source of protein vs not)

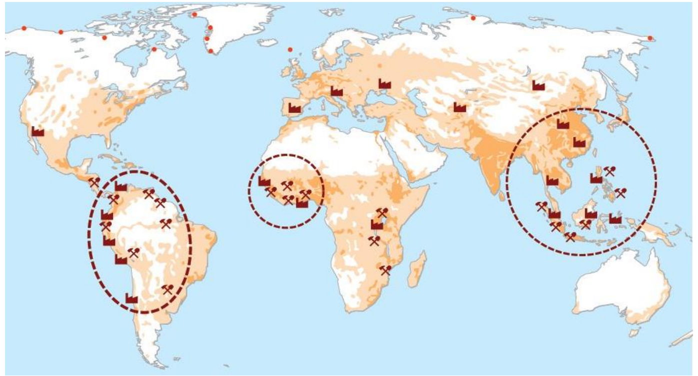
Location	THg in cord blood µg/l
Canada	5.8
Taiwan	9.1
Brazil	10.54
Poland	0.9
Turkey	0.5
Slovakia	0.8
USA (China-born Asian)	4.3 (15.8)
Japan	0.015

WHO, 2010

Biomarker mercury concentration, by country (WHO, 2017)



ASGM



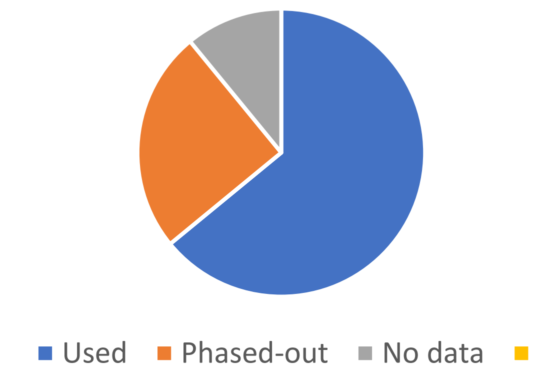
Mercury form	Toxicity
Elemental Hg^0	Acute: lungs, gastrointestinal tract
	Chronic: central nervous system, kidneys
Inorganic Hg^{2+}	Acute: gastrointestinal tract (vomiting, bloody diarrhoea), kidneys (nephritis)
	Chronic: kidneys (kidney damage), central nervous system, skin (acrodynia in children), immune system
Organic MeHg	Central nervous system, cardiovascular system

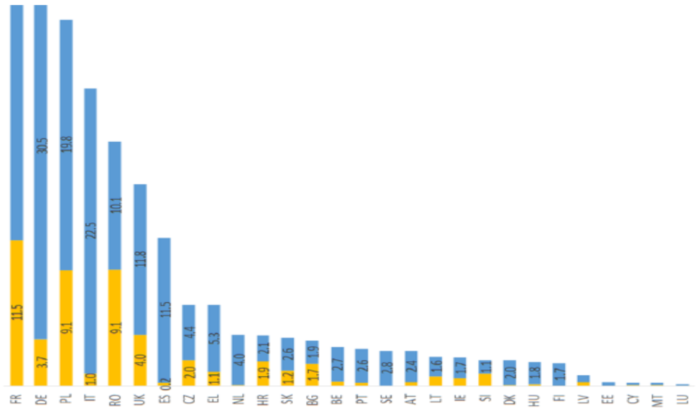
Hazard category	Hazard type	Sources of exposure	Health outcome
Chemical	Mercury (elemental)	• Mercury release during gold amalgamation and mercury removal ("burning off") processes	• Erethism (excitability) • Irritability • Excessive shyness • Insomnia • Severe salivation • Gingivitis • Tremors • Kidney disease • Acute gastrointestinal effects • From direct inhalational exposure: chemical pneumonitis, pulmonary oedema
	Mercury (methyl-)	• Mercury bioaccumulated in the environment and food chain • Consumption of mercury contaminated fish and shellfish	• Visual disturbance - e.g. scotomata, visual field constriction • Ataxia • Paresthesias (early signs) • Hearing loss • Dysarthria • Mental deterioration • Muscle tremor • Movement disorders • Paralysis and death (with severe exposure) • Prenatal exposure: fetal toxicity, cognitive and motor delays and impairment

WHO, 2016

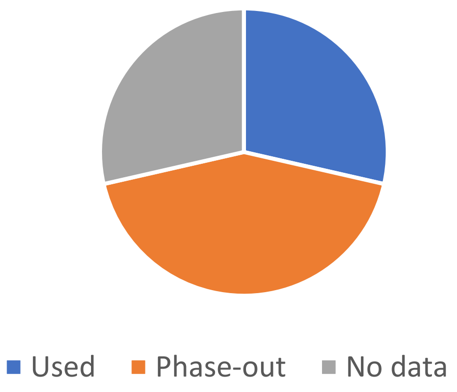
Dental amalgam

- EU (28) (2018)

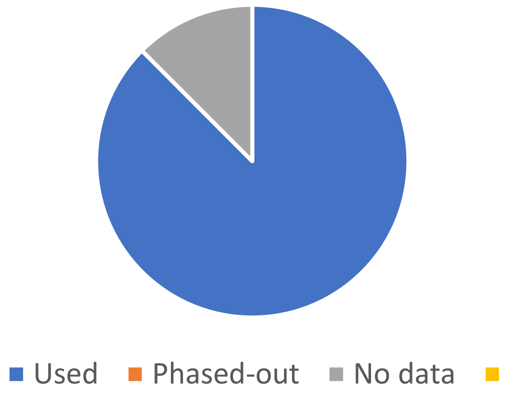


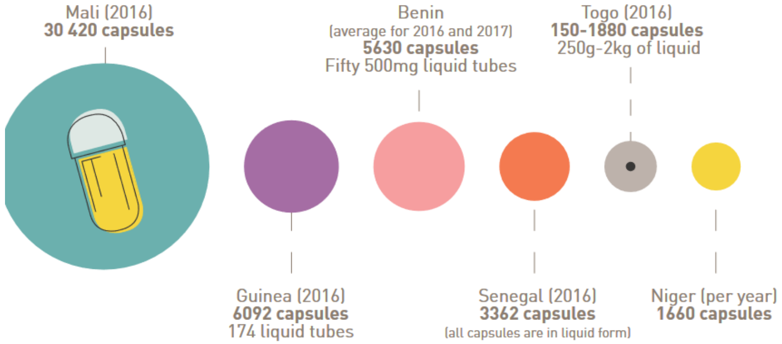


- CEE (2016-2017) (7 countries)



- AFRO (2017-2020)





25-58t /28	**64 kg/2**	**Around 5t /14**
Not used for vulnerable groups	No regulatory limits	No regulatory limits
Encapsulated form	Encapsulated form	Both (liquid mercury and encapsulated)

Skin-lightening cosmetic

- \- used worldwide, but their use is particularly widespread in many African, Asian and Caribbean countries (25-30% of population)

\- used by both women and men

\- manufactured in many countries and areas

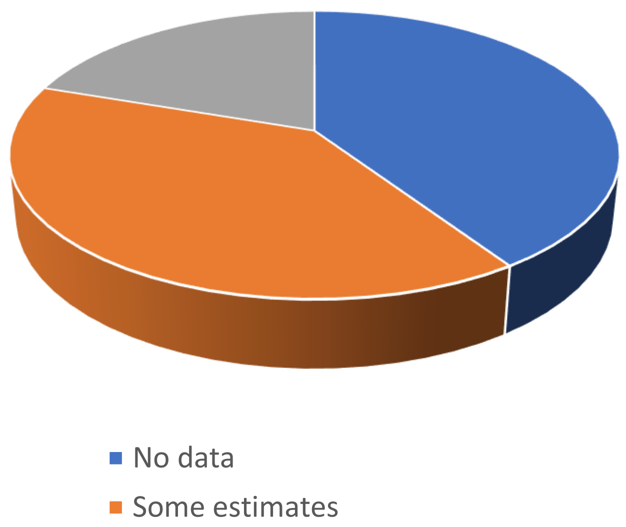
\- the mercury concentrations in these particular products ranged from 93 ppm to over 16 000 ppm (42 875 ppm)

\- Limit 1 ppm is enforced in many countries

\- No labelling, pour import control

\- Of high demand/are popular/increasing - no assessment

- \- 70% are not aware about risks



In Jamaica, 20th-month old child poisoned by mercury due to use of skin-lightening cosmetic containing 38000 ppm mercury by the mother

(Copan et al, 2015), MIA

Summary of Case Studies (with MORE planned)

	Arctic	Seychelles	Japanese	Latin America	EU	WHO
Population Characteristics	Inuit	Seafood consu mers	Seafood consumers	Background (+Vulnerable)	Background (+Vulnerable)	Background (+Vulnerable)
Key Mercury Source and Exposure Pathway	MeHg through diet (marine mammals)	MeHg through diet (ocean fish)	MeHg through diet (ocean fis h)	Various (diet, occupational, ASGM, etc.)	Various (diet, amalgam, contaminated sites)	Various (ASGM, dental, cosmetics)
Health Outcome Studies	Neurological and cardiovascular	Neurological	Neurological	Neurological	no	Neurological

Exemplify global variability; shift from historical studies linked with high exposures and adverse outcomes from a few locations, to a more diverse ones that capture a range of Hg sources, geographic and population groups, proactive and harmonized research and biomonitoring, and key socio-economic-environmental factors that underpin health.

Objective of ICMGP Synthesis Paper

- To help stakeholders (e.g., Hg scientists, Minamata Convention policy makers) gain a deeper empathy and understanding of the diversity/variance of Hg risk in populations worldwide --- from the past to the present to the future
- Present compelling "socio-environmental" case studies by leading experts
- Synthesize the information

- QUESTIONS? Moderated by Prof. Milena Horvat

MINAMATA CONVENTION ON MERCURY

Q&A

MINAMATA CONVENTION ON MERCURY

Thank you for your attention

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#MakeMercuryHistory