平成２１年度国際水銀会議スペシャルセッション開催補助業務

会議報告書

株式会社 ICS コンベンションデザイン

平成２１年７月

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開催概要

名称： 第9回国際水銀会議　スペシャルセッション

会期： 平成21年6月8日（月）～12日（金）
- ショートオーラルプレゼンテーション： 6月8日（月）13時30分～14時25分
- ポスターセッション： 6月8日（月）16時～18時30分
- キックオフミーティング： 6月8日（月）17時30分～18時
- スペシャルセッション： 6月9日（火）8時～10時5分
- レセプション： 6月9日（火）19時～20時
- 出展ブース： 6月8日（火）～12日（金）

会場： 中国貴州人民大会堂（中国貴州省貴陽市）

主催： 国立水俣病総合研究センター

6月8日（月）から12日（金）までの5日間、中国貴州人民大会堂において第9回国際水銀会議が開催された。本国際会議は、水銀に関する研究者が一堂に会し、日々の研究の発表を行うと共に、参加者相互の懇親を深めることを目的に2年に一度開催されている。本年度の国際会議において、国立水俣病総合研究センターは6月9日（火）にスペシャルセッションを主催した。また、出展も行い、来場者の毛髪水銀量分析を行った。

空港での案内デスク

中国貴州人民大会堂入口

登録デスク


オープニングセレモニー

＜ショートオーラルプレゼンテーション＞

6 月 8 日（月）13 時 30 分から 14 時 25 分まで第 4 会議室においてショートオーラルプレゼンテーションが開催された。座長は坂本峰至部長（国立水俣病総合研究センター）が務められ、研究センターより招待をしているポスター発表者 5 名が、パワーポイントを使用しプレゼンテーションを行った。本セッションには 85 名の参加者があり、大いに盛況であった。

プログラム

S01 : “Methylmercury and n-3 polyunsaturated fatty acids exposure from fish consumption”
S04 : “Socioeconomic aspects related to the mercury issue”
S22: “Mercury in polar regions”
Chair: Mineshi Sakamoto , National Institute For Minamata Disease, Minestry of Environment, Japan

TIME	Abstract Title	Authors
13:30	Nutrition transition of the Amazon Basin: Impact consumption on growth of exclusively breastfed infants during the first 5 years	Dórea, José G.(presenting author); Marques, Rejane C.; Bernardi, José V.E.; Brandão, Katiane G.; Bastos, Wanderley R.; Malm, Olaf
13:35	Total and methyl mercury in maternal and cord of pregnant women in Korea	Kim, Dae Seon(presenting author); Kang, Tack shin; Lee, Jong Haw; Hong, Young Seoub; Han, Myoung Seok; Ha, Eun Hee
13:40	Evaluating the Efficacy of Mercury Total Maximum Daily Loads on Reducing Aqueous Methylmercury Levels in Four Coastal Watersheds	Rothenberg, Sarah E.(presenting author); Ambrose, Richard F.; Jay, Jennifer A.
13:45	Socio-economic costs of continuing the status-quo of mercury pollution	Pacyna, Jozef M. (presenting author); Sundseth, Kyrre; Pacyna, Elisabeth G.; Munthe, John; Belhaj, Muhammed; Astrom, Stefan; Panasiuk, Damian; Glodek, Anna
13:50	Mercury (Hg) speciation measurements at the Zeppelin air monitoring station, Ny-Ålesund,	Berg,Torunn(presenting author); Aspmo,Katrine ; Steen,Anne Orderdalen
13:55	Mercury in hair as a biomarker of exposure in a coastal Venezuelan population	Rojas, Maritza(presenting author); Kunihiko, Nakamura; Seijas, David; Squillante, Guido; Peters, Maria; Infante, Saba
14:00	Potential contamination of mercury from artisanal gold mining in the Talawaan watershed area, north	Lasut, Markus T.(presenting author); Yasuda, Yoshiaki
14:05	Mercury and sea-run char in the Canadian Arctic: spatial patterns and temporal trends	Evans, Marlene (presenting author); Muir, Derek; Kwan, Michael; Keating, Jonathan; Gantner, Nikolaus; Wang, Xiaowa
14:10	Assessing interactions between mercury and microbial populations in the snowpack: a metagenomic approach	Larose, Catherine (presenting author); Berger, SIbel; Ferrari, Christophe; Navarro, Elisabeth; Dommergue, Aurélien; Marusczak, Nicolas; Cecillon, Sébastien; Schneider, Dominique; Vogel, Timothy M.
14:15	Reactivity and speciation of mercury in Dome Concordia	Courteaud, Julien(presenting author); Dommergue, Aurélien; Ferrari, Christophe P.
14:20	Mercury, selenium, PCBs and fatty acids in fresh and canned fish on the Slovenian market	Miklavčič, Ana(presenting author); Tratnik, Janja; Zajc, Antonija; Volk, Saša; Klavž, Janez; Kure, Viktor; Zupanc, Mojca; Stibilj, Vekoslava; Heath, Ester; Polak, Tomaž; Žlender, Božidar; Golob, Terezija;

※網掛けは研究センター招待者。
※セッション当日に発表順番の変更があった。リストは変更後の順番。

セッション会場

José Dórea 先生
(ブラジリア大学、ブラジル)

Dae-Seon Kim 先生
(ブリティッシュコロンビア大学、カナダ)

Maritza Rojas 先生
(MRM-CONSULTOX、ベネズエラ)

Markus Lasut 先生
(サム・ラトゥランギ大学、インドネシア)

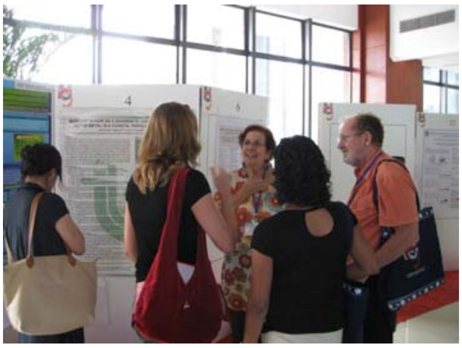
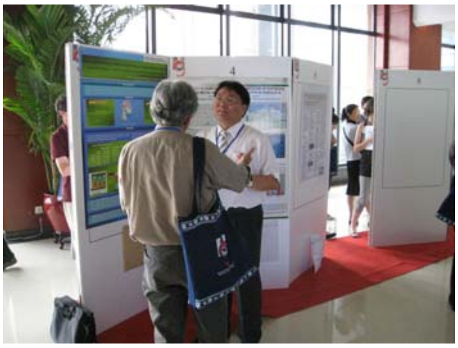
Ana Miklavčič 先生
(ヨーゼフ・ステファン国際大学院、スロベニア)

＜ポスターセッション＞

6 月 8 日（月）16 時から 18 時 30 分まで会議場 1 階ロビーにおいてポスターセッションが開催され、国立水俣病総合研究センターからの招待者の内 8 名がポスター発表を行った。ポスターセッションはフリーディスカッションであったが、終始大勢の人が訪れ熱い議論を交わしていた。

プログラム

No.	Abstract Title	Authors
M-001	Nutrition transition of the Amazon Basin: Impact of fish consumption on growth of exclusively breastfed infants during the first 5 years	Dórea, José G.(presenting author); Marques, Rejane C.; Bernardi, José V.E.; Brandão, Katiane G.; Bastos, Wanderley R.; Malm, Olaf
M-002	Total and methyl mercury in maternal and cord blood of pregnant women in Korea	Kim, Dae Seon(presenting author); Kang, Tack shin; Lee, Jong Haw; Hong, Young Seoub; Han, Myoung Seok;
M-003	Mercury, selenium, PCBs and fatty acids in fresh and canned fish on the Slovenian market	Miklavčič, Ana(presenting author); Tratnik, Janja; Zajc, Antonija; Volk, Saša; Klavž, Janez; Kure, Viktor; Zupanc, Mojca; Stibilj, Vekoslava; Heath, Ester; Polak, Tomaž; Žlender, Božidar; Golob, Terezija; Horvat, Milena
M-004	Mercury in hair as a biomarker of exposure in a coastal Venezuelan population	Rojas, Maritza(presenting author); Kunihiko, Nakamura; Seijas, David; Squillante, Guido; Peters, Maria; Infante,
M-005	Potential contamination of mercury from artisanal gold mining in the Talawaan watershed area, north Sulawesi, Indonesia	Lasut, Markus T.(presenting author); Yasuda, Yoshiaki
M-006	Methyl mercury and Omega-3 PUFA exposure from fish consumption among communities near Ethiopian Rift Valley Lakes (ERVLs): on going	Wondimkun, Solomon A.(presenting author); Sakamoto, Mineshi
M-007	Mercury levels in household members hair and in fish from fishing villages in Zhoushan, China	Cheng, Jinping(presenting author); Wang, Wenhua; Liu, Xiaojie; Sakamoto, Mineshi; Gao, Lili
M-008	Health benefits and chemical risks associated to dietary habits: Fish consumption, mercury and omega-3 fatty acids	Domingo, J.L.; Bocio, A.; Marti-Cid, R.; Llobet, J.M.; Castell, V.; Mata, E.; Marta, Schuhmacher(presenting author)

＜キックオフミーティング＞

6月8日（月）17時から18時まで第4会議室おいて、翌日開催されるスペシャルセッションの座長・演者が一堂に会しキックオフミーティングを行った。自己紹介から始まり、翌日の段取りを打合せした。このミーティングはセッションを円滑に滞りなく進行するためのミーティングであり、参加者の連帯感も生まれ、この成果は翌日のスペシャルセッションに大いに表れた。

＜スペシャルセッション＞

6 月 9 日（火）8 時から 10 時 5 分まで第 4 会議室おいて、国立水俣病総合研究センター主催によるスペシャルセッション「Methylmercury and n-3 polyunsaturated fatty acids exposure from fish consumption（魚摂食によるメチル水銀暴露と n-3 系多価不飽和脂肪酸摂取）」が開催された。座長は坂本峰至部長（国立水俣病総合研究センター）と Laurie Chan 先生（ノーザンブリティッシュコロンビア大学）が共同で務められ、8 名の研究者がそれぞれの分野での研究成果を発表した。本国際会議の中でも注目を集めているセッションでもあり、23 ヶ国 102 名の参加者が集まり、会場内は立ち見が出るほど盛況であった。質疑応答も活発であり、非常に熱のこもった議論が展開され、盛会裡の内にセッションを終えることができた。

プログラム

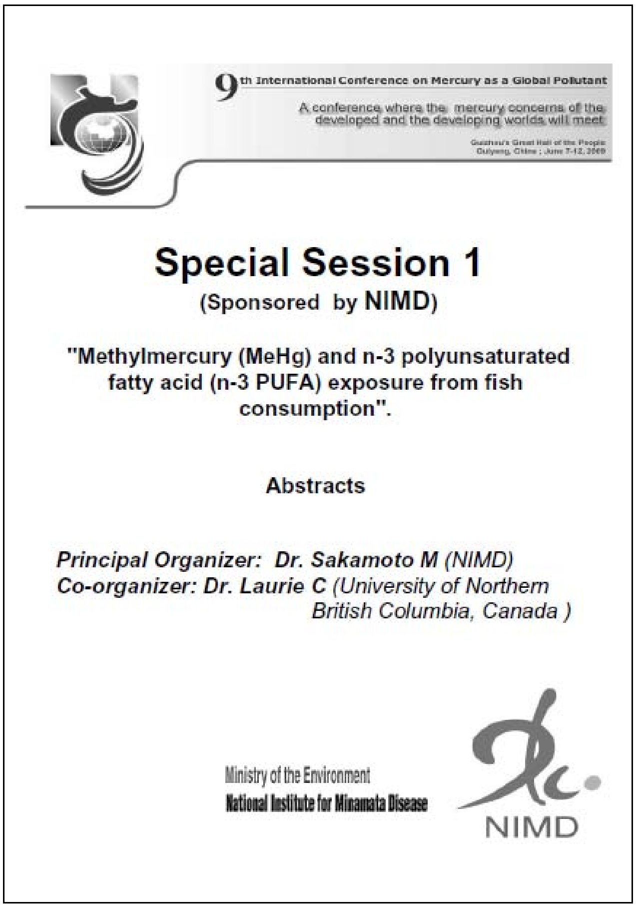
TIME	Abstract Title	Authors
8:00	Mercury exposure from fish consumption within the Japanese and Korean communities	Mariën, Koenraad(presenting author); Ami, Tsuchiya
8:20	Hair mercury: methylmercury exposure in current Japanese	Yasutake, Akira(presenting author); Hachiya, Noriyuki
8:35	Relationship between methylmercury (MeHg) and docosahexaenoic acids (DHA) in pregnant women and fetuses	Sakamoto, Mineshi(presenting author); Kawakami, Shoichi; Murata, Katsuyuki; Nakai, Kunihiko; Satoh, Hiroshi
8:50	Prenatal low levels mercury exposure on infant development: a prospective study in Zhoushan Islands, China	Yan, Chonghuai(presentingg author); Gao, Yu; Wang, Yu; Zhang, Hong; Yu, Xiaodan; Xu, Jian; Shen, Xiaoming
9:05	Methylmercury Exposure and Adverse Cardiovascular Effects	Choi, Anna L.(presenting author); Weihe, Pal; Budtz-Jørgensen, Esben; Jørgensen, Poul J.; Salonen, Jukka T.; Tuomainen, Tomi-Pekka; Murata, Katsuyuki; Nielsen, Hans Petur; Petersen, Maria Skaalum; Askham, Jórun; Grandjean, Philippe
9:20	Maternal fish intake during pregnancy, blood mercury, and child cognition at age 3 years in a US cohort	Oken, Emily(presenting author); Radesky, Jenny; Wright, Robert; Bellinger, David; Amarasiriwardena, Chitra; Kleinman, Ken; Hu, Howard; Gillman,
9:35	Omega-3 Fatty Acids and Methylmercury in Diet: Sources, Effects, and Public Health Considerations	Mahaffey, Kathryn; Sunderland, Elsie M.(presenting author)
9:50	Balancing the risk of Methylmercury and benefits of n-3 Polyunsaturated Fatty Acids Exposure from Fish Consumption	Chan, Laurie H.M.(presenting author); Choi, Anna; Mahaffey, Kathryn R.; Oken, Emily; Sakamoto, Mineshi; Yan, C.H.

国別参加人数（23 カ国 102 名）

国名	人数	国名	人数	国名	人数	国名	人数
中国	35	スロベニア	3	香港	2	スイス	1
カナダ	15	ノルウェー	3	アイルランド	1	スペイン	1
アメリカ合衆国	10	フランス	3	インド	1	デンマーク	1
ブラジル	8	イギリス	2	インドネシア	1	フィンランド	1
日本	4	スウェーデン	2	エチオピア	1	ポルトガル	1
韓国	3	ベネズエラ	2	シンガポール	1		

受付デスクでの配布物

1. アブストラクト集
2. アンケート



9th International Conference on Mercury as a Global Pollutant

A conference where the mercury concerns of the developed and the developing worlds will meet

Special Session 1

(Sponsored by NIMD)

"Methylmercury (MeHg) and n-3 polyunsaturated fatty acid (n-3 PUFA) exposure from fish consumption".

Abstracts

***Principal Organizer: Dr. Sakamoto M** (NIMD)*

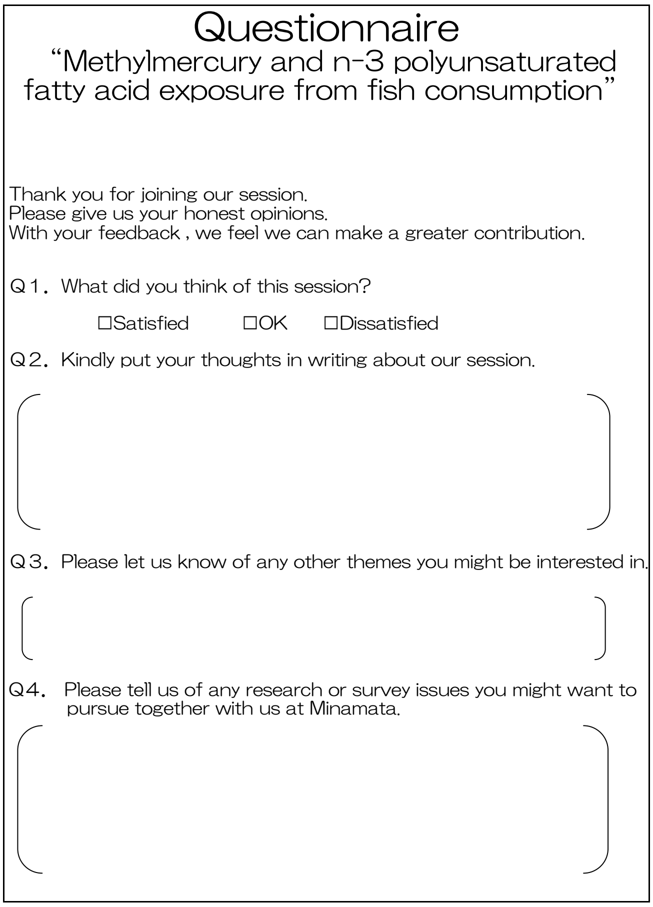
***Co-organizer: Dr. Laurie C** (University of Northern British Columbia, Canada)*

Ministry of the Environment

National Institute for Minamata Disease

NIMD

アブストラクト集（表紙）



Questionnaire

“Methylmercury and n-3 polyunsaturated fatty acid exposure from fish consumption”

Thank you for joining our session.
Please give us your honest opinions.
With your feedback , we feel we can make a greater contribution.

Q1. What did you think of this session?

□Satisfied　□OK　□Dissatisfied

Q2. Kindly put your thoughts in writing about our session.

Q3. Please let us know of any other themes you might be interested in.

Q4. Please tell us of any research or survey issues you might want to pursue together with us at Minamata.

アンケート用紙

アンケート集計結果

アンケート提出人数： 26 名

Q1. What did you think of this session?
（このセッションについてどう思われましたか。）

Satisfied（満足） 20 名
OK（まずまず） 6 名
Dissatisfied（不満足） 0 名

Q2. Kindly put your thoughts in writing about our session.
（このセッションについてのご意見をお書きください。）

1 Only viewed 2 talks. Both were very informative; 1) K. Marien + T. Ami, 2)A.Yasutake + N. Hachiya
（2 つの講演のみ聴いた。1）K. Marien 及 T.アミ、2）A.ヤスタケ及び N. ハチヤの発表は共にたいへん参考になった。）

2 Good point & good suggestions of our daily diet.
（我々の毎日の食事に関して役立つ意見や考えがあった。）

3 I would like to have more information about risk analysis
（リスク解析についての情報がもっと欲しかった。）

4 Very interesting. I think that gave good proportional of ongoing and future study in this particularly subject.
（とても興味深かった。この特定のテーマに関する研究の現状と将来像について概観することができた。）

5 Well arranged and clearly established
（よく構成されていて、立証もしっかりしていた。）

6 Wonderful, but time is so short. More presentation will be more beneficial to participants
（すばらしかったが、時間が短すぎた。発表の時間がもっとあれば、参加者により有益となるだろう。）

7 Excellent
（たいへん良かった。）

8 Excellent. Well focused bringing in the best the best
（たいへん良かった。最も良いものを最も適切に摂取することに重点がおかれていた。）

9 It was very short for the importance of the issue. Also, some more details of the study would be necessary.
（このような重要な問題を扱うには時間が非常に短かった。また本研究の詳細についてもう少し触れる必要があったと思う。）

10 Very relevant
（非常に適切だった。）

11 It is interesting
（興味深かった。）

12 Very well organized
（非常によく構成されていた。）

13 Very good presentations
（非常に良いプレゼンテーションだった。）

14 Very interesting
（たいへん興味深かった。）

15 This was the best session yet.
（今まで参加した中で最高のセッションだった。）

16 It is not necessary my major field of interest. But I was curious to find information on some of the subjects (Hair, blood determination).
（必ずしも私の主たる関心領域ではなかったが、いくつかのテーマ（毛髪・血液判定）についての情報は興味深く聴くことができた。）

17　Background information is limited
（背景となる情報が限られている。）

18　Good session. It gave a good overview of the health effects of Hg.
（良いセッションだった。水銀の健康への影響を適切に概観できた。）

19　I think you should add the kinds of fish. Maybe you can find a kind of fish which can not intake methlymercury.
（魚の種類も紹介すべきだったと思う。もしかしたら、メチル水銀を摂取しない魚を見つけられるかもしれない。）

20　The Omega-3 EGG was a bit out.
（オメガ 3 卵の話は少し疑問だ。）

21　Very good!
（たいへん良かった！）

Q3．Please let us know of any other themes you might be interested in.
（ほかに何か興味のあるテーマがあればお教えください。）

1　1) Comparison of fish vs fish oil supplements. Benefit balanced against risk would provide useful insights. 2) Studies of optimum communication of results of mercury 1 Omega- 3 ingestion survey results so as to best inform the target community
（①魚と魚油サプリメントとの比較。リスクと効果のバランスを取れば、有益な洞察が得られるだろう。 ②対象となるコミュニティに最も有益な情報を提供できるような、水銀とオメガ 3 の摂取調査結果の最も効果的なコミュニケーション手段の考察）

2　Different countries for different fish type
（国ごとで異なる魚のタイプ）

3　Mercury concentrations in predators fish. Analytical methods for HG speciation in fish samples.
（捕食魚の水銀濃度。魚試料中の水銀形態分析方法。）

4　Risk-benefit of fish consumption sources of Omega-3 and Omega-6
（オメガ 3 とオメガ 6 の供給源である魚消費のリスクと便益）

5　Relation between MeHg and Selenium
（メチル水銀とセレンとの関係）

6　Total Hg and Nutrients in fish
（魚に含まれるすべての水銀と栄養素）

7　Low level exposure of Hg and health effect
（微量水銀曝露と健康への影響）

8　I think research data on physiological consequences of the intake of Omega-3 and methyl mercury should be approached.
（オメガ 3 とメチル水銀の摂取の生理学的な影響に関する研究データを取り扱うべきだと思う。）

9　Mercury exposure and effects on high fish consuming populations (traditional)
（水銀曝露と（伝統的に）魚を多く摂取する集団への影響）

10　The new validation test to measure the congnitive effects of the exposure.
（(水銀）曝露の認知的影響を測定する新しい検証試験）

11　I am not sure
（よく分からない）

12　Animal experiments
（動物実験）

13　MeHg and other food component nutrients, antioxidents and so on
（メチル水銀とその他の食物成分、栄養素、抗酸化物質など）

14　Cultural aspects (sociology) of communication facts to mothers.
（事実を母親に伝える文化的観点（社会学)。）

15　Maybe show more data on Omega-3 levels on fresh water fish.
（できたら淡水魚のオメガ 3 のレベルについてのデータをもっと示して欲しい）

16　Session 5
（セッション 5）

17　Why contents of hair mercury in Japanese is more higher than that of other country?
（日本人の毛髪水銀値はなぜ他国のそれより高いのか）

18　As a researcher of the public health effects of low level, long-term Hg exposure, any themes covering that area are of interest.
（公衆衛生の研究者として、長期微量水銀曝露の影響、その領域に関するものであればどのようなテーマでも関心がある。）

19　How often we eat the fish and do not affect our health?
（どのような頻度で魚を食べれば、体に悪影響を与えないか）

20　Hg/Se; Hg/I
（水銀とセレン、水銀とヨウ素）

21　Disruption cellular neurodevelopment and behavior.
（細胞の神経発達破壊と挙動）

Q４．　Please tell us of any research or survey issues you might want to pursue together with us at Minamata.
（水俣で当方とともに従事したいと思われるような研究・調査課題があればお教えください。）

1　Probabilistic risk assessment. (I) am currently guiding a PhD student conducting survey + analysis for an African -American community in coastal Virginia, USA
（確率論的リスク評価。（私は）米国のバージニア州沿岸地域のあるアフリカ系アメリカ人のコミュニティの調査・分析を行っている博士過程の学生を現在指導している。）

2　1)Revocery of the M.D.　2) global distribution, transportation, and cooperation of Hg research.
（①水俣病の克服　②水銀研究の国際的分配、伝達、協力。

3　Benefit of Omega-3 rich food and Selenium supplementation to the health status of affected population
（被害者の健康状態に対するオメガ３を多く含む食品とセレンサプリメントの効果）

4　Considering how to avoid the bad side of MHg and make full application of n-3 polyunsaturated fatty acid.
（どうしたら、メチル水銀がもたらす悪影響を避け、n-3 系不飽和脂肪酸を十分に活用できるか）

5　Low level exposure of Hg in general population and health effect
（一般の人々における微量水銀曝露と健康への影響）

6　To study interference of Omega-3 in adult and embryonic neurogenesis of methlymercury contaminated animals.
（メチル水銀に汚染された動物（成人および胎児）のニューロン新生に対するメガ 3 の干渉効果の研究）

7　If we assume Hg as a global pollutant, I think we have to find out the situation on developing countries. Most data presented here are from developed countries.
（水銀が地球汚染物質だとすると, 私たちは発展途上国の現状について知る必要がある。 今回発表されたデータのほとんどは先進国のものであった。）

8　Animal experiments with PAFac & EPA
（PAFac と EPA（エイコサペンタエン酸）を使った動物実験）

9　Hg trophic transfer in marine fish
（海水魚類の水銀移行）

10　Perhaps in the future
（将来その可能性もある）

11　Total evaluation of nutrients and toxicants altogether
（栄養素と毒物物質の総合評価）

12　Cellular neurodeveopment of the embrions and adult rats
（胚と成人ラットの細胞レベルの神経発達）

受付デスク

会場内

参加者

座長の坂本部長と Chan 先生

Koenraad　Mariën 先生
（ワシントン州保健省、米国）

安武　章　室長
（国立水俣病総合研究センター、日本）

坂本　峰至 部長
（国立水俣病総合研究センター、日本）

Chonghuai Yan 先生
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＜レセプション＞

6 月 9 日（火）19 時より、貴州飯店 1 階レストランにてレセプションを開催した。招待者、国立水俣病総合研究センター職員の総勢 28 名が集まり、スペシャルセッションが盛会裡に終了したことを祝し懇談を行った。

＜出展ブース＞

6 月 8 日（月）より 12 日（金）まで、会議場 1 階展示ホールにおいて展示会が行われ、国立水俣病総合研究センターも出展を行った。佐々木眞敬部長を中心に運営を行い、研究センター、分析技術、国際貢献の紹介ポスターをブース壁面に展示し、液晶モニターを利用し研究内容を紹介するスライドショーを行った。また、来場者へは研究センターの案内パンフレット、熊本県の観光と農産物パンフレット、水俣市の観光パンフレットの配布を行った。当ブースは立地がよい上、出展内容も興味を惹かれるものが多く、期間中に延べ 904 名の来場者があった。

毛髪水銀測定

当展示ブースにおいては、来場者の方々より毛髪を頂戴し、毛髪内の水銀量の測定を行った。測定は同じく出展していた LUMEX 社にご協力いただき、測定結果を即日報告することができた。この測定には会議参加者より非常に高い関心をいただき、開催期間中に 214 名の方が測定を行われた。なお、毛髪提供者には研究センターのエコバッグを進呈した。

来場者数及び毛髪則定数

単位： 名

	6月8日	6月9日	6月10日	6月11日	6月12日	合計
来場者数	371	226	106	172	29	904
毛髪則定数	109	51	20	34	–	214

National Institute for Minamata Disease

CALL FOR HAIR SAMPLES

National Institute for Minamata Disease studies on the mercury-pollution in developing countries. Hair is clearly the most suitable material for estimation of methylmercury exposure.

Mercury content in hair will be analyzed by a flameless atomic absorption spectrometer in the institute for free and the mercury data will be sent to you promptly by E-mail.

We also need the identification number, sex and age of a participant, sampling site and fish consumption data.

First of all, please contact to: Dr. M. Fujimura.

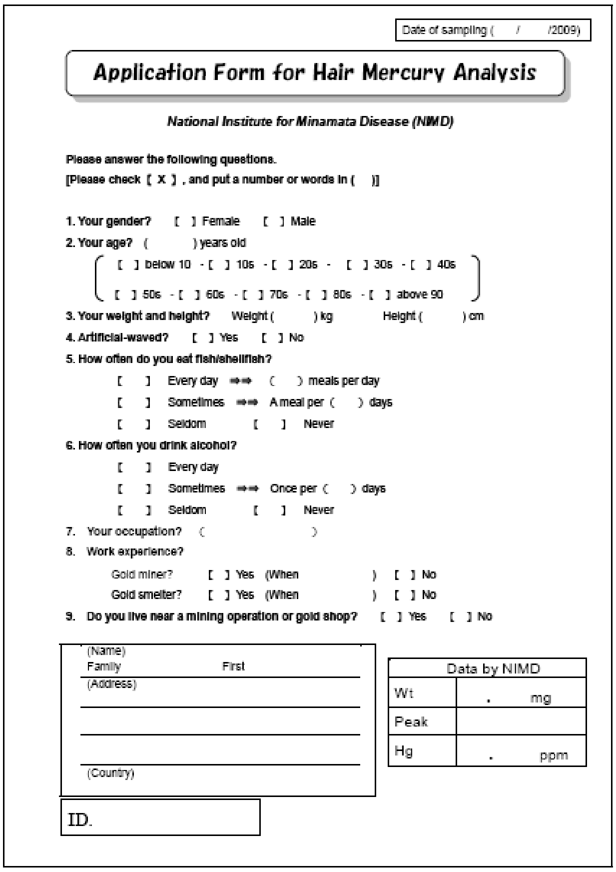
E-mail : fujimura@nimd.go.jp

at Department of Basic Medical Sciences,
National Institute for Minamata Disease,
Minamata, 4058-18 Hama, Kumamoto, 867-0008, Japan.

NIMD

Please send us hair samples.
We use the hair samples only for mercury determination.

毛髪水銀測定案内



Date of sampling (　/　/2009)

Application Form for Hair Mercury Analysis

National Institute for Minamata Disease (NIMD)

Please answer the following questions.
[Please check [X] , and put a number or words in (　)]

1. Your gender?　[ ] Female　[ ] Male
2. Your age?　(　) years old
[ ] below 10 - [ ] 10s - [ ] 20s - [ ] 30s - [ ] 40s
[ ] 50s - [ ] 60s - [ ] 70s - [ ] 80s - [ ] above 90
3. Your weight and height?　Weight (　) kg　Height (　) cm
4. Artificial-waved?　[ ] Yes　[ ] No
5. How often do you eat fish/shellfish?
[ ] Every day ⇒⇒ (　) meals per day
[ ] Sometimes ⇒⇒ A meal per (　) days
[ ] Seldom　[ ] Never
6. How often you drink alcohol?
[ ] Every day
[ ] Sometimes ⇒⇒ Once per (　) days
[ ] Seldom　[ ] Never
7. Your occupation? (　)
8. Work experience?
Gold miner?　[ ] Yes (When　)　[ ] No
Gold smelter?　[ ] Yes (When　)　[ ] No
9. Do you live near a mining operation or gold shop?　[ ] Yes　[ ] No

(Name)
Family　First
(Address)
(Country)

Data by NIMD	
Wt	. mg
Peak	
Hg	. ppm

ID.

アンケート用紙

アンケート集計結果

国別人数	人
中国	90
カナダ	26
アメリカ合衆国	20
ノルウェー	11
韓国	9
ブラジル	8
スペイン	6
スェーデン	6
フランス	5
日本	4
インド	3
ロシア	3
チェコ共和国	2
フェロー諸島（デンマーク）	2
フィンランド	2
クロアチア	1
エチオピア	1
ドイツ	1
インドネシア	1
イスラエル	1
イタリア	1
マレーシア	1
スロベニア	1
スイス	1
台湾	1
イギリス	1
ベネズエラ	1
未記入	5
合計	214

質問1．性別	人
女性	95
男性	116
未記入	3
合計	214

質問2．年代	人
10代以下	2
20代	81
30代	53
40代	30
50代	29
60代	13
70代	2
未記入	4
合計	214

質問2．年齢	人
21	3
23	3
24	13
25	7
26	7
27	6
28	13
29	5
30	6
31	1
32	4
33	6
34	1
35	3
36	3
37	5
38	3
39	1
40	3
41	1
42	1
43	3
44	4
47	4
49	2
50	3
51	2
52	2
53	1
54	2
55	3
56	2
57	2
58	3
59	2
60	1
61	3
62	1
63	1
65	2
68	1
72	1
未記入	74
合計	214

質問3．体重(Kg)	人
13	1
42	1
43	1
44	1
46	2
47	1
48	2
49	1
50	15
51	2
52	5
53	5
54	4
55	9
56	7
57	9
58	3
59	2
60	17
61	3
62	4
63	4
64	2
65	12
67	2
68	3
69	2
70	8
72	4
73	5
74	2
75	15
76	2
77	2
78	1
79	1
80	10
81	2
82	2
83	2
84	2
85	4
86	3
88	3
90	7
92	1
95	3
96	1
97	1
100	2
104	1
105	1
110	2
未記入	7
合計	214

質問3．身長(cm)	人
84	1
125	1
150	3
152	4
153	1
154	2
155	6
156	3
157	5
158	6
160	13
161	2
162	6
163	10
164	4
165	11
166	3
167	2
168	8
169	2
170	16
171	9
172	7
173	6
174	5
175	12
176	3
177	4
178	10
179	2
180	8
181	5
182	2
183	3
185	4
186	1
187	1
190	1
191	1
193	1
195	2
198	1
200	1
未記入	17
合計	214

質問4．パーマもしくはカラーリングの有無	人
あり	30
なし	164
未記入	20
合計	214

質問5．魚を食べる頻度	人
毎日食べる	12
ときどき食べる	160
あまり食べない	33
まったく食べない	5
未記入	4
合計	214

質問5．魚介類を食べる頻度
※毎日食べる人の場合

回数/日	人
1	6
2	1
3	1
未記入	4
総計	12

質問5．魚介類を食べる頻度
※時々食べる人の場合

回数（○日に1回）	人
0.5	1
1	1
2	11
3	36
2～3	1
4	17
3～4	1
5	14
4～5	1
6	2
7	30
6～7	1
8	1
10	12
14	2
15	5
10～15	1
1週間に2回	2
20	2
30	1
60	2
180	1
未記入	15
合計	160

質問6．飲酒の頻度	人
毎日飲む	20
ときどき飲む	100
あまり飲まない	67
まったく飲まない	22
未記入	5
合計	214

質問6．飲酒の頻度
※時々飲酒の場合

回数（○日に1回）	人
0.5	1
1	1
2	22
3	15
2～3	1
4	7
5	7
6	4
7	14
10	6
14	4
15	2
20	3
30	1
60	1
未記入	11
合計	100

質問7．職業（職種）	人
学生（院生含む）	68
研究者	25
科学者	18
教授	13
教師	11
化学者	6
研究科学者	5
事務員	3
生物学者	2
医師	3
水銀分析者	3
水銀研究者	2
科学研究者	2
研究助手	2
講師	2
営業	2
行政官	1
分析オペレーター	1
准教授	1
准教授／科学者	1
助教	1
コンサルタント	1
エコノミスト	1
編集者	1
教育	1
技術者	2
研究者（環境）	1
研究所所長（マネージャー）	1
博士（化学）	1
衛生学者	1
疫学者	1
毒物学者	1
実験論者	1
科学者兼市町村長	1
政府関係	1
国家公務員	1
マネージャー	1
ミーティングマネージャー	1
サービス業	1
ソーシャルワーカー	1
主婦	1
無職	1
未記入	20
合計	214

質問8．金鉱での労働経験	合計
あり	3
なし	200
未記入	11
合計	214

質問8．製錬所での労働経験	合計
あり	0
なし	201
未記入	13
合計	214

質問9．金鉱や金関係の職務経験	合計
あり	3
なし	189
未記入	22
合計	214

Thank you for your kind cooperation

Hair Hg level in your hair is:

______.______ ppm

【Reg. No. :　　　　　　　　】

【DATE: June _____ 2009】

According to WHO, there is no health effect for adults with hair Hg level up to 50 ppm.

For pregnant women, any fetal effect will be impossible with hair Hg level below 14 ppm.

Average hair Hg levels in Japanese are 2.5 and 1.6 ppm for males and females, respectively.

If you are interested in hair Hg, please contact us.

National Institute for Minamata Disease (NIMD)
Ministry of the Environment
Japan

TEL　+81-966-63-3111
FAX　+81-966-61-1145
Email　mail@nimd.go.jp

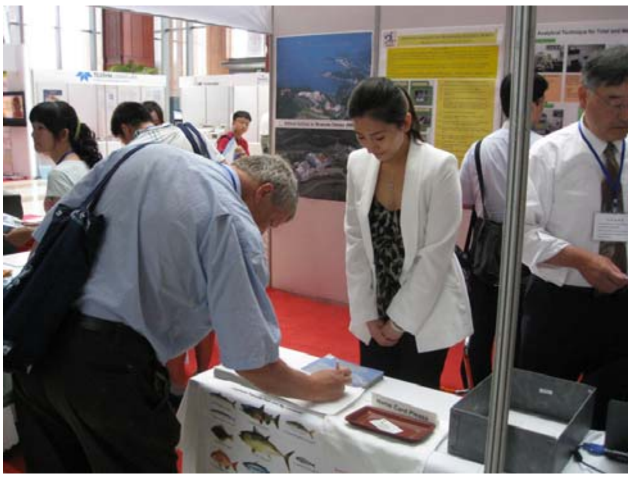
毛髪水銀量報告用紙

ブース全体

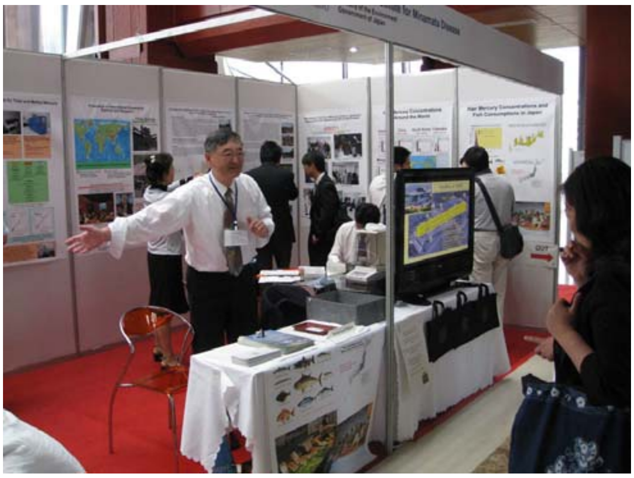
受付デスク

熊本・水俣観光資料

スライドショーによる紹介



受付風景



賑わうブース①

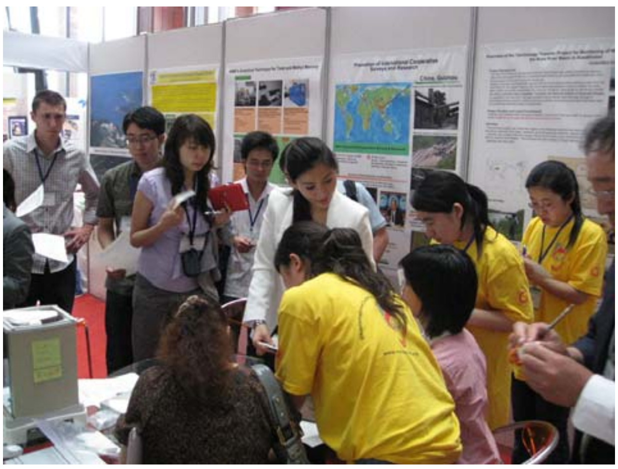
賑わうブース②

賑わうブース③

パネルに見入る来場者

毛髪重量測定器

毛髪採取



毛髪水銀測定結果報告

スペシャルセッション

プロシーディングス
発表データ

Fish intake guidelines: n-3 fatty acid intake and contaminant exposure in the Korean and Japanese communities

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[c] Washington State Department of Health, Olympia, Washington, USA

Abstract

Most fish consumption guidance is based on preventing exposure to contaminants. However, fish provides nutrients that are essential to optimal growth and health. We examined high end fish consumers who were women of childbearing age living in the U.S. to determine how intake of n-3 polyunsaturated fatty acids relates to mercury (Hg) exposure and how the relationship can impact fish consumption guidance. Hg fish tissue concentrations for species consumed, hair-Hg levels, and fish, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) intake levels were obtained for individuals from with the Japanese and Korean communities (n=214). Fish intake for both communities was close to the 95th percentile for the US general population. Hair Hg levels were also above the national average. Although total finfish consumption rates between the two populations were similar, Hg intake between the two is significantly different. The observed differences in fish-species consumption behavior and Hg intake levels between the two populations suggest that Asian populations should not be grouped as a whole, but treated independently. In addition, consumption patterns suggest that within both populations, there may be a percentage of individuals not obtaining their daily dietary requirement of DHA or DHA+EPA. Fish consumption guidelines based on contaminant concentrations alone can have the unintended consequence of causing a portion of the population to have an insufficient intake of required nutrients. Public health goals may be better served if nutritional elements and contaminant concerns are quantitatively incorporated into fish consumption guidelines.

1. Introduction

The US Environmental Protection Agency (USEPA) has established a reference dose (RfD) of 0.1 ug/kg/day for methylmercury. Because fish is the most prominent source of non-occupational mercury (Hg) exposure in our diet, regulatory agencies worldwide have developed fish consumption guidelines derived from established reference doses or tolerable intakes. Accordingly, most public health guidelines are based on preventing overexposure by providing fish consumption advice .

Along with concern over contaminant exposure, fish consumption is also associated with improved health (Akabas and Deckelbaum 2006; Cohen et al. 2005). Fish are a major source of n-3 polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid which, are thought to play important roles in neurodevelopment (Akabas and Deckelbaum 2006; Hibbeln et al. 2006). The optimal intake of DHA is thought to be between 100 and 300 mg per day for women (Akabas and Deckelbaum 2006). For DHA and EPA together the optimal intake is considered to be between 400 and 500 mg per day (Gebauer et al. 2006; Kris-Etherton et al. 2002).

Recently, studies have investigated the risk-benefit aspects of seafood consumption; with results being inconclusive (Budtz-Jorgensen et al. 2007; Nesheim et al. 2007; Sakamoto et al. 2004). In this work we attempt to better understand this issue by examining high end fish consumers consisting of women of childbearing age living in the U.S. to determine how the intake of PUFAs relates to Hg exposure and how this relationship can impact fish consumption guidance.

2. Subjects and Methods

As part of the Arsenic Mercury Intake Biometric Study, women of childbearing age who identified themselves as Korean, Japanese participated in the longitudinal study. The recruitment and sample collection methods have been previously described in detail (Tsuchiya et al. 2008). Participants were asked to identify fish species consumed and provide amounts and frequency of consumption for each species. Hair was collected for Hg analysis. DHA and EPA intakes were estimated based on consumption.

3. Results and Discussion

A total of 214 women of childbearing age (106 Japanese and 108 Koreans) participated. Mean finfish intake for Japanese was 60 g/d and 59 g/d for Koreans with mean total seafood intakes being 73 g/d and 82 g/d, respectively. Intake levels were not significantly different ($p<0.05$)

**Presenter's e-mail addressl:koenraad@doh.wa.gov*

between communities. These seafood intakes were close to the 95th percentile for the U.S. general population as provided from National Health and Nutrition Examination Survey data (Mahaffey et al. 2004).

The species consumed by the populations were markedly different. Finfish species most consumed by the Japanese were: salmon (29 % of total intake), mackerel (9%), black cod (6%), squid (6%), light tuna (canned) (5%) and halibut (4%). Species most consumed by the Korean population were: squid (23%), mackerel (12%), yellow croaker (11%), salmon (9%), flounder/sole (6%), and light tuna (canned) (6%). In addition to the differences in species consumed, hair-Hg levels differed significantly between the communities.

The mean hair-Hg level for the Japanese was 1.6 ppm with 55 % of the population exceeding the USEPA RfD of 1.2 ppm. However, the mean hair-Hg level for the Korean population was 0.75 ppm and only 13% exceeded the RfD. The difference in Hg exposure is likely due to the differences in type of fish species consumed.

Intakes of DHA and EPA were plotted against hair-Hg levels. For the Japanese community, 40 individuals (38%) did not meet the recommended DHA + EPA intake and of those, 12 individuals (11%) exceeded the RfD. Within the Korean community, 62 individuals (57%) did not meet the recommended DAH+EPA intake. However, only 5 (5%) exceeded the RfD. Our results suggest that both communities consumed fish in large quantity, yet a portion of each population did not meet DHA + EPA recommended intake on a daily bases. Therefore, these two populations could benefit from fish consumption guidance that includes information on minimizing Hg exposure as well as on the benefits of fish consumption so as to reduce both Hg exposure while also reducing the number of individuals not obtaining the recommended levels of n-3 PUFAs. Further, the guidance should be population specific as the Japanese need to reduce their Hg exposure while increasing DHA+EPA intake. In contrast, the Korean population needs to increase their intake of fatty fish species that are low in Hg and have no restrictions placed on fish consumption. The observed differences between the two populations in regards to fish consumption behavior, hair-Hg levels, DHA/EPA intake and recommended public health guidance on fish consumption suggests that Asian populations should not be grouped as a whole, but treated independently.

4. References

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Tsuchiya A, Hardy J, Burbacher TM, Faustman EM, Mariën K. 2008. Fish intake guidelines: incorporating n-3 fatty acid intake and contaminant exposure in the Korean and Japanese communities. The Americ J of Clinical Nutrition 87(6):1867-1875.

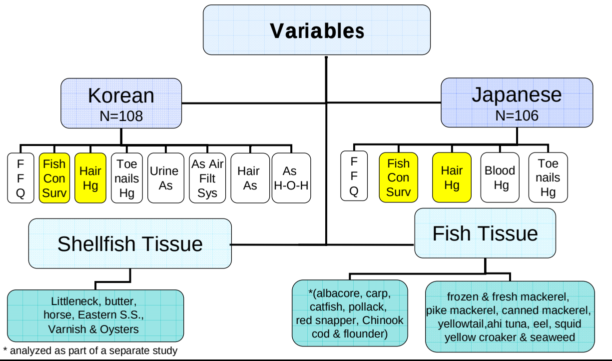
発表データ

Fish Intake Guidelines: n-3 Fatty Acid Intake And Contaminant Exposure In The Korean and Japanese Communities

Washington State Department of Health
&
University of Washington
PNW Center for Human Health and Ocean Studies
&
Institute for Risk Analysis and Risk Communication

Arsenic Mercury Intake Biometric Study

(Data for this presentation are highlighted in yellow)



Objectives of This Study

To determine:

- fish consumption patterns and mercury exposure among high fish consumers living in the U.S.
- how the intake of n-3 FAs relates to mercury exposure
- how the results impact fish consumption guidance

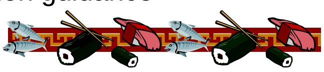


Photo credit: Microsoft Clipart

Subjects

- Subjects were recruited in western Washington from Aug 05 to Dec 06
- Inclusion Criteria:
  - Women of childbearing age (18-45)
  - Japanese/Korean or of Japanese/Korean descent
  - Lived in the western Washington area for more than 6 months

Fish Intake Comparison:
Japanese and Korean populations

	Finfish			Shellfish			Finfish & Shellfish combined		
	Mean	50th %	95th %	Mean	50th%	95th %	Mean	50th%	95th %
Japanese (n=106)	**60**	43	**159**	14	9	59	73	55	188
Korean (n=108)	**59**	49	**147**	23	13	84	82	64	230

g/person/day

Fish Intake Comparison:
to National Statistics

	Finfish			Shellfish			Finfish & Shellfish combined		
	Mean	50th%	95th %	Mean	50th%	95th %	Mean	50th%	95th %
Japanese (n=106)	60	43	159	14	9	59	**73**	55	188
Korean (n=108)	59	49	147	23	13	84	**82**	64	230
US General (CSFII[1])							14		**72**
US General (NHANES[2])							1.8*		**87**

g/person/day

1:Jacobs 1997, 2: Mahaffey 2004 , *geometric mean

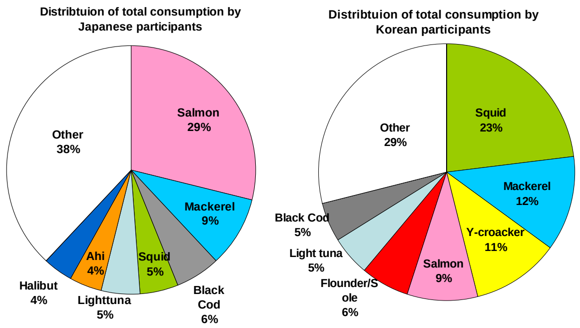
Estimated Hg Intake & Hg Hair levels Comparison

				Percentiles			
		n	Mean	50th	75th	90th	95th
Estimated Hg Intake (ug/kg/d)	Japanese	106	0.14	0.09	0.18	0.25	0.37
	Korean	108	0.07	0.05	0.09	0.15	0.19
	US General (NHANES 1999-2000[1])	1,727	0.02*	NA	0.0	0.04	0.13
Hair Hg (ppm)	Japanese	106	1.57	1.37	1.96	2.68	3.52
	Korean	108	0.75	0.67	1.02	1.29	1.52
	US General (NHANES 1999-2000[2])	1,727	0.47	0.19	0.42	1.11	1.73

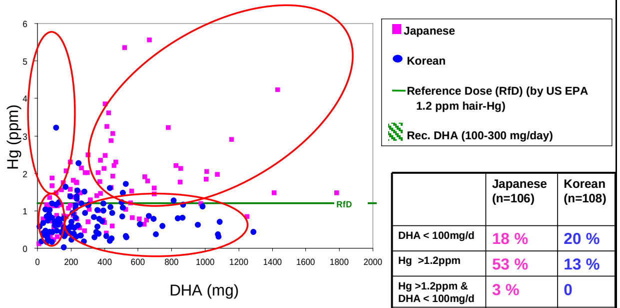
1:Mahaffey 2004, 2:McDowell 2004, *geometric mean

Fish intake- by weight

Species contributing the largest % to total consumption

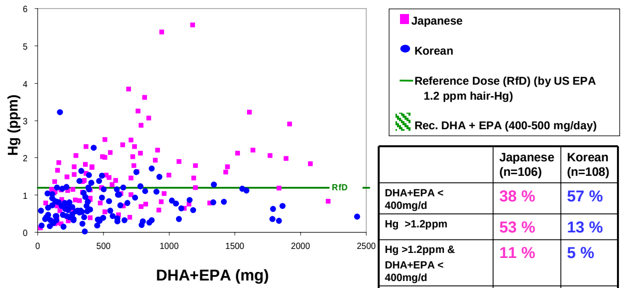


DHA intake & Hg exposure



	Japanese (n=106)	Korean (n=108)
DHA < 100mg/d	18 %	20 %
Hg >1.2ppm	53 %	13 %
Hg >1.2ppm & DHA < 100mg/d	3 %	0
Hg >1.2ppm & DHA >300mg/d	38 %	8 %
Hg < 1.2ppm & DHA <100mg/d	15 %	20 %

DHA+EPA intake & Hg exposure



	Japanese (n=106)	Korean (n=108)
DHA+EPA < 400mg/d	38 %	57 %
Hg >1.2ppm	53 %	13 %
Hg >1.2ppm & DHA+EPA < 400mg/d	11 %	5 %
Hg >1.2ppm & DHA+EPA >500mg/d	40 %	8 %
Hg < 1.2ppm & DHA+EPA <400mg/d	26 %	54 %

Results Summary

- Fish intake and Hg exposure levels were above the 95th percentile levels to national levels
- Nearly identical amounts of finfish intakes
  - ~ 60 g/person/day
  - Consumed different types of fish
- Different Hg exposure levels
  - 55% of Japanese vs.13% of Korean exceed US EPA's RfD for mercury
- Large % do not obtain recommended DHA or DHA+EPA levels
  - ~20% did not consume daily rec DHA, larger for DHA+EPA

Recommendations

- Asian populations should not be grouped as a whole, but treated independently
- The goal of fish consumption guidance should ensure that optimal health is achieved
  - Not just minimize exposure to the contaminant
  - Nutritional elements and contaminant concerns need to be quantitatively incorporated (into fish consumption guidelines)

Hair mercury: current methylmercury exposure in Japan

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Abstract

Hair mercury level is an excellent marker for methylmercury (MeHg) exposure, since a portion of MeHg is highly and stably accumulated there. We have been conducting a survey on hair mercury contents among general populations from 14 districts to estimate the current Japanese MeHg exposure level. The total hair mercury levels collected varied with age and sex. The geometric means for the population without artificial waving were 2.47 and 1.65 ppm for males (n = 5623) and females (n = 3470), respectively. The age-dependent variation in the hair mercury levels well fit to fish consumption feature. Since no difference was observed in the fish consumption rates (g/day/kg body weight) between male and female, some hormonal contribution might be involved in the mercury uptake by human hair. The average mercury levels in our hair samples varied among the sampling districts in Japan; the eastern districts tend to show higher levels than western districts. Consumption rate of tuna, the major carnivorous fish consumed in Japan, might be responsible for the regional variation.

Recently, a provisional tolerable weekly intake (PTWI) of MeHg was revised considering an effect on fetus. WHO and Japanese Government suggested the levels corresponding to hair levels of 2.2 and 2.8 ppm, respectively. Our results showed that a considerable portion of females at child-bearing age, 15 to 49 years old, were estimated to be exposed to MeHg above these levels. This would reflect the high Japanese consumption of marine products. However, not only the risk of mercury contamination, but also food habits and nutritional benefits, such as poly-unsaturated fatty acids, may have to be considered when determining a regulatory standard of fish and shellfish.

Keywords: hair mercury; Japanese population; methylmercury exposure; PTWI; fish consumption

1. Inroduction

Methylmercury (MeHg) is formed by saprophyte microorganisms from inorganic mercury compounds in the aquatic environment (ATSDR, 1992). It is accumulated in fish and shellfish through the marine food web. Since the MeHg accumulation increases with the food web, carnivorous fish such as tuna, swordfish and shark often exhibit high levels of mercury. Accordingly, the major route of human exposure to MeHg is the ordinary consumption of fish and shellfish.

In Japan, the provisional regulatory standards of mercury and MeHg in fish and shellfish were determined in 1973 to be 0.4 and 0.3 ppm, respectively, based on the assumption of a safe intake limit of 0.17 mg mercury/person/week (0.48 μg/kg bw/day). On the other hand, due to high susceptibility of the developing fetus, the exposure limit of MeHg has been suggested for pregnant women. Based on the results from cohort studies in the Faroe Islands and the Seychelles, a provisional tolerable weekly intake (PTWI) of MeHg was determined to be 1.6 μg mercury/kg/week using an uncertainty factor 6.4.at the 61st meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2003). Very recently, the PTWI for pregnant women has also revised in Japan to 2.0 μg mercury/kg/week (MHLW 2005). However, a considerable segment of the Japanese population is thought to be exposed to MeHg in excess of the above levels due to their habitually high consumption of marine products (Yasutake et al., 2003; 2004). Here we reported on a survey of the hair mercury levels in a cross section of representative Japanese sub-populations to estimate the current MeHg exposure levels in Japan.

2. Subjects and Methods

Hair samples were collected during 2000 to 2004.from 12,923 individuals (0 to 95 years old, 6,477 females and 6446 males) in 14 districts of 12 prefectures: Hokkaido (Abashiri and Tomakomai Cities), Miyagi, Chiba, Niigata, Saitama, Nagano, Wakayama, Tottori, Hiroshima, Fukuoka, Kumamoto (Kumamoto and Minamata Cities), and Okinawa. Using a questionnaire, we gathered information from each individual on 1) age, 2) sex, 3) frequency of fish and shellfish serving, 4) amount of fish taken per serving, 5) fish species often served, 6) presence of artificial waving, and 7) presence of hair-coloring. Total mercury levels were determined according to the oxygen combustion-gold amalgamation method using an atomic absorption mercury detector.

3. Results and Discussion

Distribution of total mercury levels in the hair samples collected varied form 0.012 ppm to 40.2 ppm. Since an artificial waving effectively removed some of the hair mercury (Yamamoto and Suzuki, 1978; Yasutake, et al., 2003), the waved hair samples were removed. The mean values for subpopulations without artificial waving were 2.47 and 1.65 ppm for males (n = 5623) and females (n = 3470), respectively. These levels were somewhat higher than those estimated from mercury concentrations in blood or toenails recently reported in western countries (Sanzo, et al., 2001; Guallar, et al., 2002; CDC, 2003). Hair mercury levels varied with age in both sexes, but such variations were more significant in males. Following a transient decline around the 20s, male levels increased into their 50s and 60s, and declined thereafter. The highest levels in the 50s and 60s were mostly twice those in childhood. The age-dependent variation in male hair mercury well fit to fish consumption feature. On the other hand, the age-dependent variations in females were less significant. Although the difference between sexes was not evident at younger ages, the significant increase with age in male mercury levels accounted for a notable sex difference after the age of puberty. Since the amount of fish consumption shown as per body weight was found to be equal between male and female, it could not account for the sex difference in the hair mercury levels.

The geometric means for the population without artificial waving were 2.47 and 1.65 ppm for males (n = 5623) and females (n = 3470), respectively. The hair mercury levels varied with age, and the variations were more significant in males. Following a transient decline around the 20s, the levels increased into their 50s and 60s, and declined thereafter. The highest levels of males in the 50s and 60s were mostly twice those in childhood. The age-dependent variation in the hair mercury levels well fit to fish consumption feature. The difference between sexes was not evident at younger ages, and no difference was observed in the fish consumption rates (g/day/kg body weight) between male and female. These suggested that some hormonal contribution might be involved in the mercury uptake by human hair. Multiple regression analysis revealed that mercury levels were significantly correlated with several covariates, such as sex, age, the amount of daily intake of total fish/shellfish, a preference for certain fish such as tuna or bonito, and artificial waving.

The average mercury levels in our hair samples varied among the sampling districts in Japan; the eastern districts tend to show higher levels than western districts. The level in the highest Chiba was more than twice of the lowest Fukuoka. Tuna is a major carnivorous fish with high mercury accumulations that is often consumed in Japan, and its consumption rate is higher in the eastern districts. The amount of fish consumption and the preference rate for tuna would appear to be responsible for the regional variation in hair mercury levels in Japan.

Recently, a provisional tolerable weekly intake (PTWI) of MeHg was revised considering an effect to fetus by 61st JECFA (FAO/WHO Joint Expert Committee on Food Additives) to 1.6 μg/kg/week, which was about half that of the Japanese standard, and corresponded to a hair level of 2.2 ppm. In 2005 Japanese Government also revised PTWI levels for pregnant women to 2.0 μg/kg/week, corresponding to a hair level of 2.8 ppm. The distribution of hair mercury levels in Japanese populations in the present study indicated that 25% and 15% of the Japanese females of child-bearing age, 15 to 49 years old, were estimated to be exposed to MeHg above the PTWI levels of 61st JECFA and Japan, respectively. This would reflect the high Japanese consumption of marine products. However, not only the risk of mercury contamination, but also food habits and nutritional benefits, such as poly-unsaturated fatty acids, may have to be considered when determining a regulatory standard of fish and shellfish. Accordingly, sufficient and accurate information for general population must be provided to reach an appropriate decision on fish consumption. Hair analysis may, at least in part, contribute to such decisions by providing information on the MeHg exposure levels of each individual.

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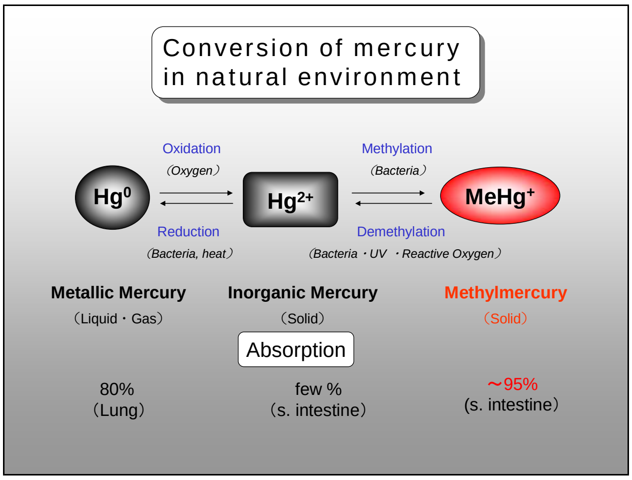
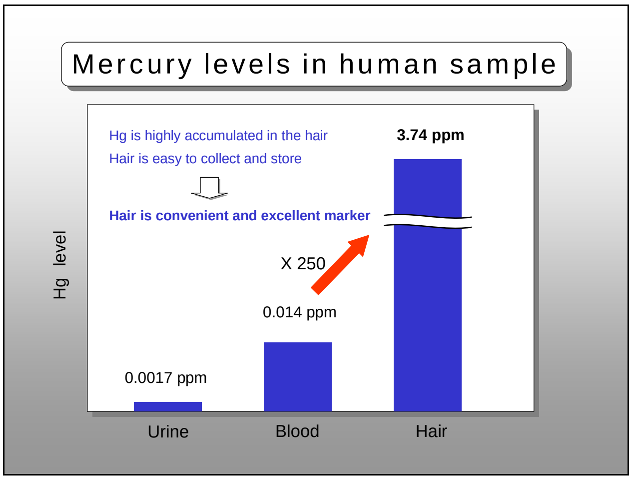
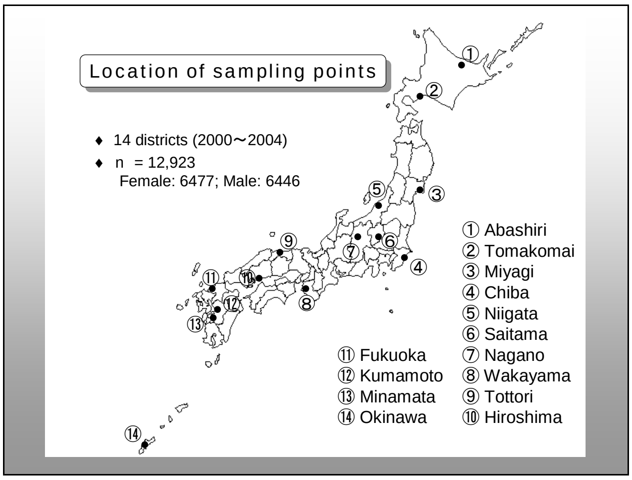


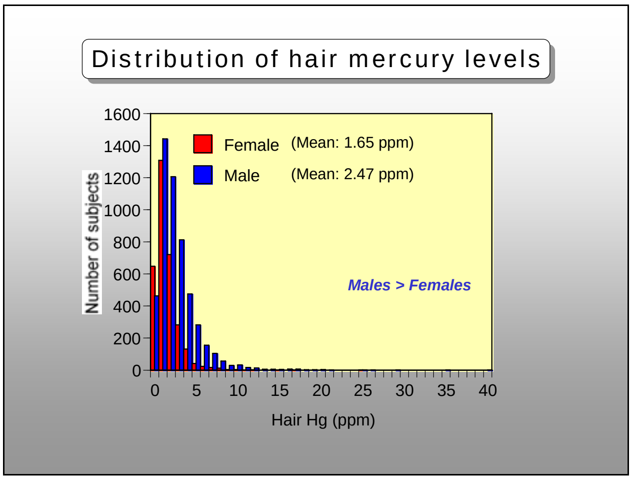
Conversion of mercury in natural environment
Oxidation
(Oxygen)
Reduction
(Bacteria, heat)
Methylation
(Bacteria)
Demethylation
(Bacteria・UV ・Reactive Oxygen)
Hg0
Hg2+
MeHg+
Metallic Mercury
(Liquid・Gas)
Inorganic Mercury
(Solid)
Methylmercury
(Solid)
Absorption
80%
(Lung)
few %
(s. intestine)
～95%
(s. intestine)



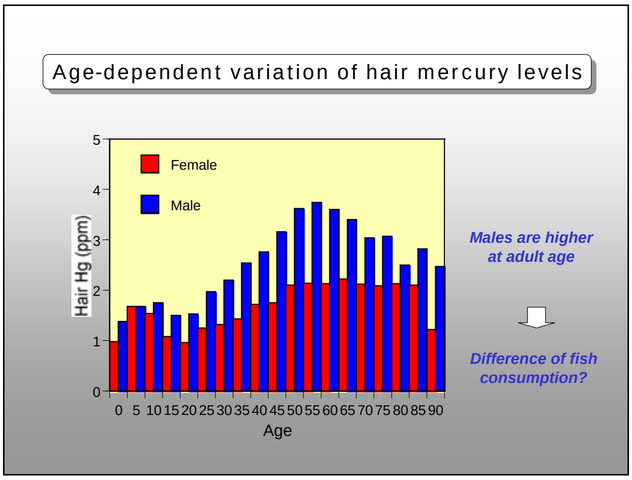
Mercury levels in human sample
Hg is highly accumulated in the hair
Hair is easy to collect and store
Hair is convenient and excellent marker
3.74 ppm
X 250
0.014 ppm
0.0017 ppm
Hg level
Urine
Blood
Hair



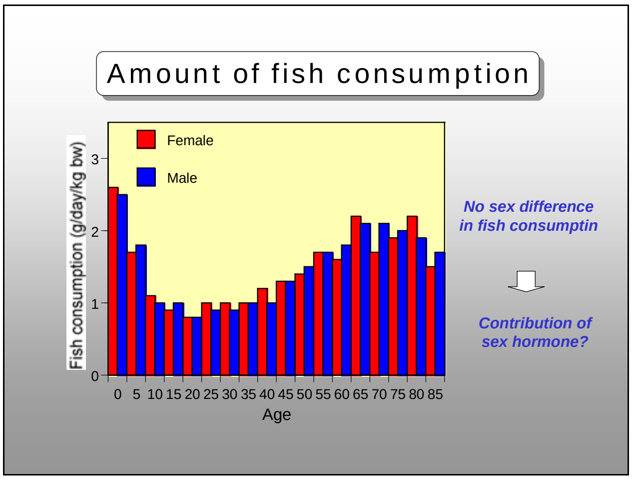
Location of sampling points
♦ 14 districts (2000～2004)
♦ n = 12,923
Female: 6477; Male: 6446
① Abashiri
② Tomakomai
③ Miyagi
④ Chiba
⑤ Niigata
⑥ Saitama
⑦ Nagano
⑧ Wakayama
⑨ Tottori
⑩ Hiroshima
⑪ Fukuoka
⑫ Kumamoto
⑬ Minamata
⑭ Okinawa



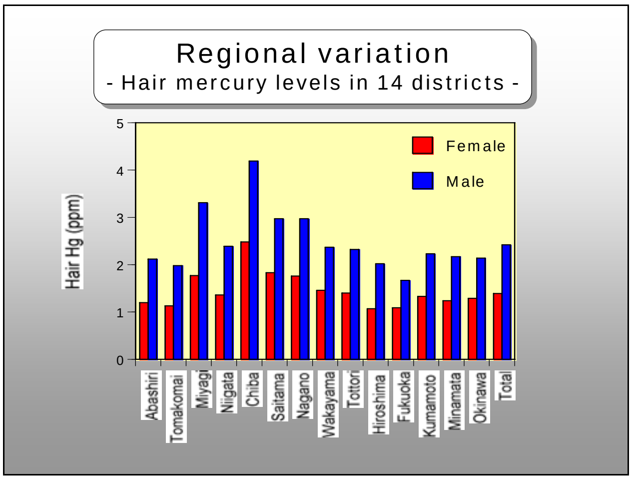
Distribution of hair mercury levels
Female (Mean: 1.65 ppm)
Male (Mean: 2.47 ppm)
Males > Females
Number of subjects
Hair Hg (ppm)

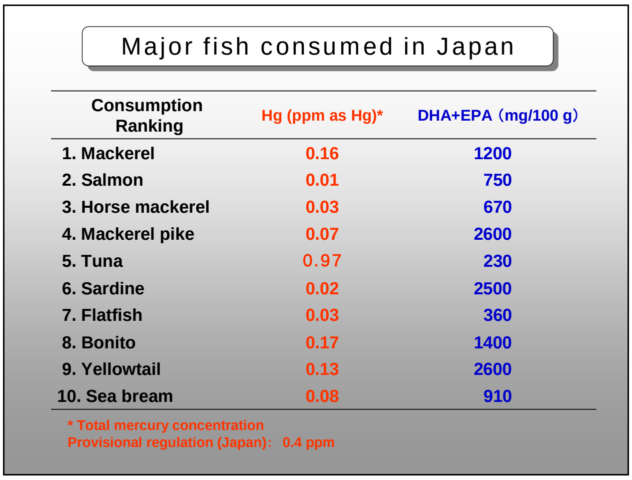


Age-dependent variation of hair mercury levels
Female
Male
Hair Hg (ppm)
Age
Males are higher at adult age
Difference of fish consumption?



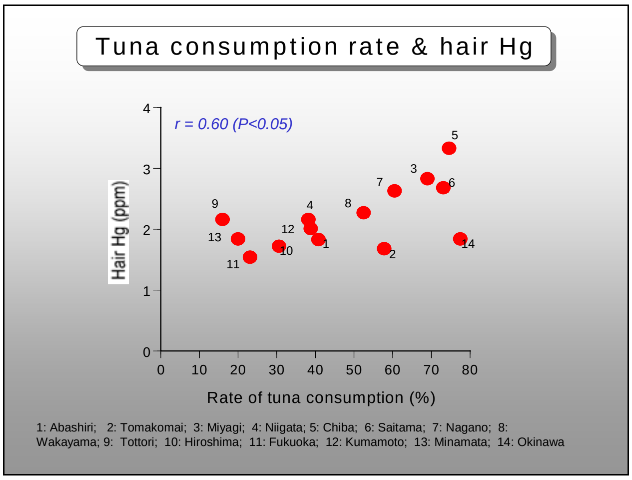
Amount of fish consumption
Female
Male
Fish consumption (g/day/kg bw)
Age
No sex difference in fish consumptin
Contribution of sex hormone?

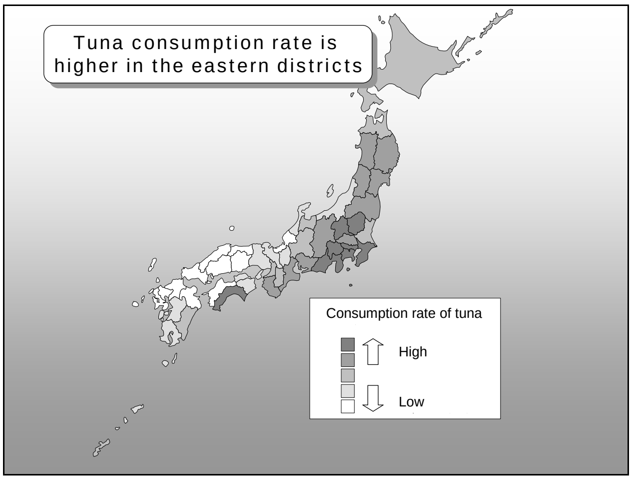




Consumption Ranking	Hg (ppm as Hg)*	DHA+EPA（mg/100 g）
1. Mackerel	0.16	1200
2. Salmon	0.01	750
3. Horse mackerel	0.03	670
4. Mackerel pike	0.07	2600
5. Tuna	0.97	230
6. Sardine	0.02	2500
7. Flatfish	0.03	360
8. Bonito	0.17	1400
9. Yellowtail	0.13	2600
10. Sea bream	0.08	910

* Total mercury concentration
Provisional regulation (Japan): 0.4 ppm





Relationship of methylmercury (MeHg) and docosahexaenoic acid (DHA) in pregnant women and fetuses

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Abstract

This study was designed to determine the relationship between methylmercury (MeHg) exposure and docosahexaenoic acid (DHA) concentrations in pregnant women and fetuses to consider the risk and benefit of maternal fish consumption during the gestation period. Venous blood samples were collected from 55 pairs of mothers from early gestation, and mothers and fetuses (cord blood) at parturition. Total mercury (Hg) in blood and fatty acids in plasma were measured. Maternal Hg level showed a tendency to decline from early gestation to parturition. Cord blood Hg level was about 1.8 times higher than mothers. Significant positive correlations with Hg (r=0.78) and DHA (r=0.67) were observed between mother and fetuses, indicating that both substances in fetuses reflect maternal exposures. Significant positive correlations of Hg and DHA were observed in mothers both at early gestation (r=0.29) and at parturition (r=0.36). A significant positive correlation with MeHg and DHA was also observed in cord blood (r=0.36). These results confirm that both Hg and DHA which originated from fish consumption transferred from mothers to fetus and they existed in the fetal blood with a positive correlation. Pregnant women in particular need not give up eating fish to obtain such benefits. However, they would do well to at least consume smaller fish, which contains less MeHg, thereby balancing the risks and benefits from fish consumption.

Keywords: methylmercury, heavy metals, placental transfer, red blood cells, cord blood

1. Inroduction

Methylmercury (MeHg) is a well known and widespread environmental neurotoxicant. In the natural course of events, most human exposure to MeHg is through fish and sea mammal consumption. Generally, the larger fish and sea mammals at the top of the food chain, such as shark, tuna and whale, contain higher levels of MeHg than the smaller ones. Fetuses are known to be a high-risk group for MeHg exposure since the susceptibility of the developing brain itself is high. Therefore, the effect of MeHg exposure on pregnant women remains an important issue for elucidation, especially in populations which consume much fish and sea mammals.

On the other hand, human intake of the n-3 longer chain of polyunsaturated fatty acids (PUFA), such as eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3), is also known to be produced originally by phytoplankton, mainly from fish consumption. Both of these fatty acids are very beneficial for human health. Especially, DHA is known to be an important n-3 PUFA for normal brain development and function. Rapid brain growth occurs primarily during the third trimester in humans, and the amount of these fatty acids increases dramatically during the period. This period corresponds to when the human brain is most susceptible to MeHg, and also a high accumulation of MeHg in the brain may occur during the period.

We conducted a study mainly to determine the relationship between Hg and plasma fatty acid concentrations in mothers and fetus to evaluate the risks and benefits of maternal fish consumption by comparing 55 maternal-fetal pairs of blood samples.

2. Subjects and Methods

Fifty-five healthy Japanese pregnant women without any particular exposure to Hg provided informed consent to participate in the present trial approximately at early gestation. These women ranged in age from 19 to 40 years (average age 29.3 ± 4.8 years), and resided in Kumamoto City, Kumamoto, Japan. Blood and hair samples were collected at early gestation and at parturition from the mothers. Cord blood samples were collected immediately after birth.

Fatty acid composition analysis in plasma was immediately performed by SRL Inc. (Tokyo, Japan). Blood samples were stored at -80°C until total Hg (THg) analysis. This study was

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approved by the Ethics Committee of the National Institute for Minamata Disease (NIMD). Total Hg in 0.5 g of blood was determined by cold vapor atomic absorption spectrophotometry (CVAAS) according to the method of Akagi (Akagi et al., 2000).

3. Results and Discussion

MeHg is one of the substances most risky to fetal brain development, and most of the exposure to MeHg is through maternal fish consumption (IPCS, WHO 1990). On the other hand, DHA, which is important for the fetal brain and its growth, is also derived from maternal fish consumption. If human exposure to MeHg were independent of nutrition from fish, we would aim at zero exposure. However, fish plays an important cultural role among Japanese and contains n-3 polyunsaturated fatty acids, such as DHA and EPA. Therefore, this study was designed to determine the relationship between MeHg exposure and DHA concentrations in pregnant women and fetuses to consider the risk and benefit of maternal fish consumption during the gestation period.

MeHg and DHA levels in cord blood showed the tendency to increase with fish intake (g/day). Significant positive correlations with MeHg (r=0.78) and DHA (r=0.67) were observed between maternal and cord blood, indicating that both substances in fetuses reflect maternal exposures. Cord blood Hg level was about 1.8 times higher than mothers at parturition. This suggests that MeHg actively transfers to the fetus across the placenta via neutral amino acid carrier (Ashner, M., Clarkson, T.W 1988), when the fetus is most susceptible to MeHg. Therefore, the effect of MeHg exposure remains an important issue for elucidation, especially in populations which consume much fish and sea mammals. Maternal Hg levels at early gestation and at parturition showed a significant positive correlation (r=0.53). However, the level showed a tendency to decline from early gestation to parturition, indicating that high amount of MeHg transfers from mothers to fetuses through placenta during gestation.

DHA and arachidonic acid (AA) are abundant in the brain. During rapid brain growth, large amounts of DHA and AA from the maternal circulation must reach the fetus to meet its needs for development. The rapid quantitative accretion of both DHA and AA during the third trimester of pregnancy was noticed in human brain. Breast-milk also contains these fatty acids. Our data showed that the fetal/maternal ratio of DHA and AA are higher than other fatty acids, which are not important for brain, indicating that the fatty acids which are important for the brain and its growth were selectively transferred from maternal blood to cord blood.

Though the origins of the two fatty acids are completely different, DHA showed significant positive correlations with AA, which is also important for fetal brain and its growth. This phenomenon is interesting, and it may suggest that the ratio of these fatty acids is also important.

Hair/blood Hg ratios were 356 at early gestation, 339 at partition, and higher than 250 at the steady state, which indicates that MeHg distribution can not be explained by a single-compartment model. This must be taken into consideration in risk assessment of MeHg during gestation.

Significant positive correlations of MeHg and DHA were observed in mothers both at early gestation (r=0.29) and at parturition (r=0.36). A significant positive correlation with MeHg and DHA was also observed in fetuses (r=0.36). These results suggest that they were derived from fish consumption and were selectively transferred from mothers to fetuses. These results indicate that both MeHg and DHA, which act contrary to the normal growth and function of the developing brain, were taken into the maternal blood through maternal fish consumption and transfer to fetal blood, and that they showed positive correlations. Therefore, if the ordinary fish consumed are low in MeHg but rich in DHA, children's health will especially benefit from the fish consumption. However, if the fish MeHg concentration is high enough to ruin the effect of DHA, fish consumption will retard children's development. Pregnant women in particular would do well to consume at least smaller fish, thereby reducing the risk from large fish but allowing them to continue to eat them in order to confer the benefits.

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Relationship of methylmercury (MeHg) and docosahexaenoic acid (DHA) in pregnant women and fetuses

Mineshi Sakamoto
NIMD

Background

- MeHg is one of the most risky substances to fetal brain development, and most of the exposure to MeHg is through maternal fish consumption.
- High-risk group to MeHg exposure is fetus
- LOAEL (Lowest Observed Adverse Effect Level) is recognized to be 10-14 ppm in pregnant maternal hair

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- On the other hand, Docosahexaenoic acid (DHA, 22:6n-3), which is important for the fetal brain and its growth, is also derived from maternal fish consumption.
- If human exposure to MeHg were independent of nutrition from fish, we would aim at zero exposure.
- However, fish plays an important cultural role among Japanese and contains n-3 polyunsaturated fatty acids (n-PUFA), such as DHA and eicosapentaenoic acid (EPA, 20:5n-3).

Objective

- to determine placental transfer of maternal MeHg and DHA, and to determine how the fetal levels reflect the maternal levels
- to examine the relationship between DHA and MeHg in maternal blood circulations at early gestation and birth.
- to examine the relationship between DHA and MeHg in cord blood circulations.

,though the magnitude of the effects

Methods *Samples* ; 55 pairs in Kumamoto City

At Early Gestation

Maternal venous blood

Maternal hair 1 cm from scalp

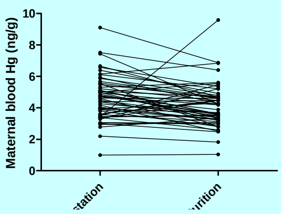
At Birth

Maternal venous blood

Umbilical cord (fetal) blood

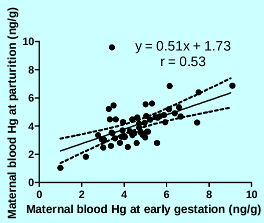
Maternal hair 1 cm from scalp

Hg in whole blood ; Fatty acid in plasma were measured in the paired samples.



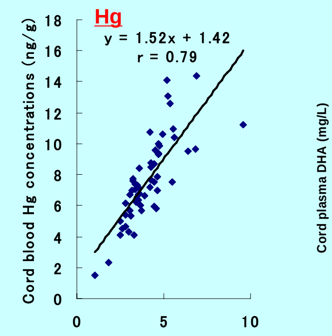
Early gestation   Birth

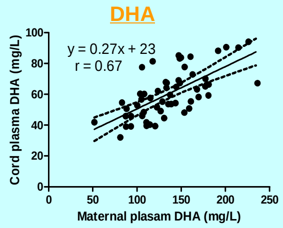
Birth



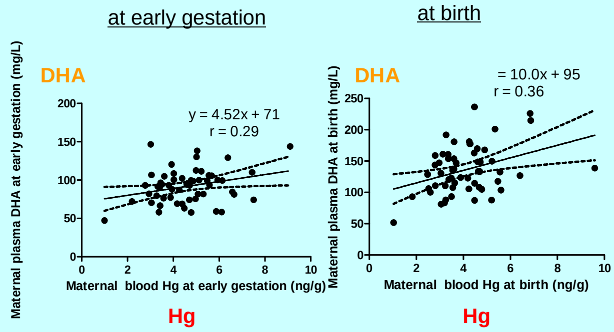
Early gestation

Relationship between maternal blood Hg concentration at early gestation and birth

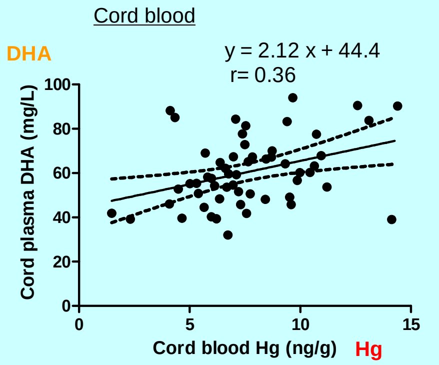




Correlations of Hg and DHA levels between maternal and cord blood at birth



Correlation between maternal blood Hg and plasma DHA at early gestation and birth



Correlation between Hg and DHA in cord blood

Conclusion 1

- We can conclude that the levels of fetal MeHg and DHA, which derived from fish consumption and act contrary to the developing brain, reflect the maternal levels and they show a positive correlation in fetal blood circulation.

Conclusion 2

- We can conclude that the levels of fetal MeHg and DHA, which derived from fish consumption and act contrary to the developing brain, reflect the maternal levels and they show a positive correlation in fetal blood circulation.
- This indicate that fish contains both MeHg and DHA as a risk and benefit, and both of them in fetal blood circulation increase according to the amount of maternal fish intake.

Recommendation

Yes, fish contain MeHg. However, pregnant women do not need to give up eating fish, they should continue to eat them in order to confer the benefit, but, should consume smaller fish in order to reduce the risk from large fish.

DHA, EPA

Prenatal low levels mercury exposure on infant development: a prospective study in Zhoushan Islands, China

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Shanghai 200092, China

Abstract

Objective To explore the relationship between prenatal mercury exposure and infant neurodevelopmental outcomes in Zhoushan cohort. **Material and methods** 408 mother-infant pairs were enrolled in the cohort of Zhoushan Islands. Prenatal mercury exposure was determined by measuring cord blood mercury (CBHg, Range 1.34-18.34μg/L). Based on their CBHg, children were divided into two groups: 80 in low mercury group (LMG, CBHg<P20, 3.98μg/L), and 84 in high mercury group (HMG, CBHg>P80, 8.09μg/L). Children were followed up at 3 (n=149) and 12 (n=123) months mos. of age evaluated with BSID, hair mercury and questionnaire. The association between CBHg concentrations and neurodevelopmental outcomes at 3 and 12 months of age was examined by multiple regression analysis with adjustment for confounding variables. **Results** The average hair mercury levels were 1058.71±69.58μg/kg in LMG, and 1903.06±139.37μg/kg in HMG of 3-month-infant and 906.05±110.26 μg/kg in LMG, and 1512.41±93.85μg/kg in HMG of 12-month-infant. The hair mercury of 12-month were lower than that of 3-month significantly in both group. The CBHg were related significantly with hair mercury in 3 mos. and 12 mos., and the r value were 0.684 and 0.460 respectively of three and 12 mos. (p value were all less than 0.01) in spearmen correlation analysis. MDI of 3-month-infant were 109.01±4.16 of LMG, 108.32±4.23 of HMG, PDI were 99.91±3.28 of LMG, and 98.71±5.21 of HMG. MDI of 12-month-infant were 110.60±4.29 of LMG, 109.56±4.29 of HMG, PDI were 104.06±3.75, and 101.70±3.59 of HMG. There were no significant differences of MDI and PDI between the two groups in both ages. The high risk factors at 3 months for MDI were hair mercury of 3 months and head circumference; and those for PDI were hair mercury of 3 months and gender. The high risk factors for MDI scores of 12 months were hemoglobin of 3 months, age when children stood up and those for PDI were age when children stood up, average times of fish dinners of mother in pregnancy and hemoglobin levels of 12 months. **Conclusions** The CBHg was significantly related with hair mercury level at 3 and 12 mos. The mercury exposure level of 12-month-infant was lower than that of 3-month-infant. Prenatal low level mercury exposure had very subtle impact on infants' development.

Keywords: mercury, heavy metals, cord blood, development, prospective study

1. Introduction

Inorganic mercury (Hg) is ubiquitous in the global environment .It discharged into lakes, rivers and oceans. From pollution it can be converted to Methylmercury (MeHg) by microorganisms and is bioaccumulated up to the aquatic food chain. Ingested MeHg is almost totally absorbed and readily cross the placenta and blood-brain barriers. MeHg is highly and selectively toxic to the central nervous system (CNS). The prenatal period is believed to be the most susceptible stage of life cycle. The most common form of prenatal exposure is maternal fish consumption. For susceptible people, such as pregnant women, nursing mothers, and young babies consume some fish containing higher levels of Hg may harm the developing nervous system. Whether prenatal exposure to Hg from ocean fish and other seafood is associated with an increased risk of neurodevelopmental deficit has raised concern, but the outcomes are controversial. Zhoushan city is an ocean fishery foundation in China, where 80% residents consume ocean fish daily. The study is testing the hypothesis that prenatal exposure to low concentrations of methylmercury from maternal diet in fish is related to the children's developmental outcomes.

2. Subjects and methods

In Aug to Sep, 2004, 408 mother-infant pairs were enrolled at Third people hospital in Dinghai region, Zhoushan City. All the pairs in the study were written consents and completed a questionnaire. When the neonates were 3 days old, we excluded 24 neonates for testing NBNA: one had 5-min Apgar scores lower than 8, one had intrauterine growth retardation, and 22 had neonatal jaundice. In total, 384 3-day-old newborns were assessed on the neonatal behavioral neurological assessments (NBNA).

The hair samples were collected from mothers about 1–3 days after delivery. Hair in the first 3 cm (next to the scalp) was cut from the occipital area with stainless steel scissors. The samples were placed in a plastic bag and kept in a desiccator until analysis. About 1mL of umbilical cord blood was collected in an Ependoff tube (10 mL 7% EDTA was added in advance as an anticoagulant) using a sterilized syringe and stainless steel needle combination, then was homogenized and stored at -20 centi-degree immediately.

All the total mercury levels of mother's hair and cord blood were determined Hg analyzer: Direct Mercury

Analyzer 80 (Italy, Milestone Company) with quality control procedures.

Dependent on the cord blood mercury levels (CBHg), the infants were divided into three groups, whose CBHg were equal or higher than 80 percentage(HMG), between 20 to 80 percentage(MMG), and equal or lower than 20 percentage(LMG).

Infants in HMG (n=84) and LMG (n=80) were followed up by evaluated with Bayley Scales of Infant Development (BSID), analyzed hair mercury and investigated questionnaire at 3 month (n=149) and 12 (n=123) month age.

3. Results

Results

The geometric mean (GM) of Hg level in cord blood was 5.58μg/L(interquartile range: 3.96–7.82μg/L), and the GM of maternal hair Hg level was 1246.56μg/kg (interquartile range: 927.34–1684.67μg/kg).

Fish intake frequency during pregnancy was associated with both maternal hair Hg ($r = 0.48$, $P<0.001$) and cord blood Hg levels ($r=0.54$, $P<0.001$). We found statistically significant differences in both maternal hair and cord blood Hg levels among groups with different fish consumption frequencies ($F=53.56$ for cord Hg and 40.86 for maternal hair Hg, both $P<0.01$).

The average hair mercury levels were 1058.71±69.58μg/kg in LMG, and 1903.06±139.37μg/kg in HMG of 3-month-infant and 906.05±110.26 μg/kg in LMG, and 1512.41±93.85μg/kg in HMG of 12-month-infant. The hair mercury of 12-month were lower than that of 3-month significantly in both group. The CBHg were related significantly with hair mercury in 3 mos. and 12 mos., and the r value were 0.684 and 0.460 respectively of three and 12 mos. (p value were all less than 0.01) in spearmen correlation analysis. MDI of 3-month-infant were 109.01±4.16 of LMG, 108.32±4.23 of HMG, PDI were 99.91±3.28 of LMG, and 98.71±5.21 of HMG. MDI of 12-month-infant were 110.60±4.29 of LMG, 109.56±4.29 of HMG, PDI were 104.06±3.75, and 101.70±3.59 of HMG. There were no significant differences of MDI and PDI between the two groups in both ages. The high risk factors at 3 months for MDI were hair mercury of 3 months and head circumference; and those for PDI were hair mercury of 3 months and gender. The high risk factors for MDI scores of 12 months were hemoglobin of 3 months, age when children stood up and those for PDI were age when children stood up, average times of fish dinners of mother in pregnancy and hemoglobin levels of 12 months.

4. Discussion

Methylmercury can be transferred to the fetus through the placenta before birth and to newborn offspring through breast milk after birth. It has been known that Hg concentrations in milk are very low, and that 55–80% of Hg in milk is in the inorganic form, which is less indigestible by the intestinal tract than MeHg.

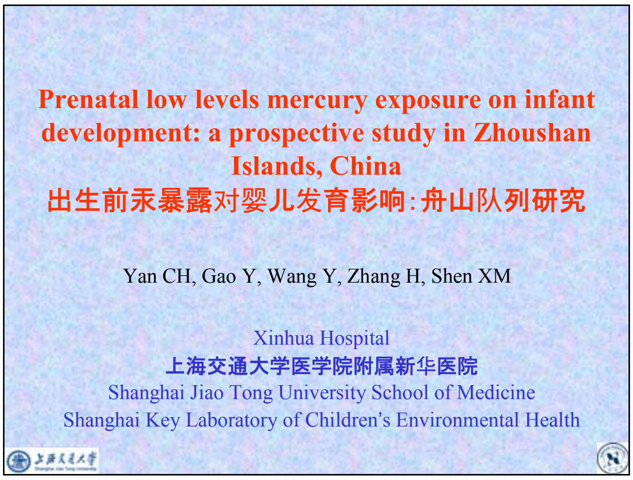
In our study, we found the factors influencing MDI score were hair mercury of 3 months, head circumference, HB of children at 12 months age that children can stand and children having pneumonia or not; while those of PDI were hair mercury of 3 months, gender, age that children can stand, fish dinners of mother and HB of children at 12 mos. of age. Except for hair mercury level of infants, fish dinners of mother, other factors are all factors that can reflect or influence children development, so they can affect MDI, PDI scores.

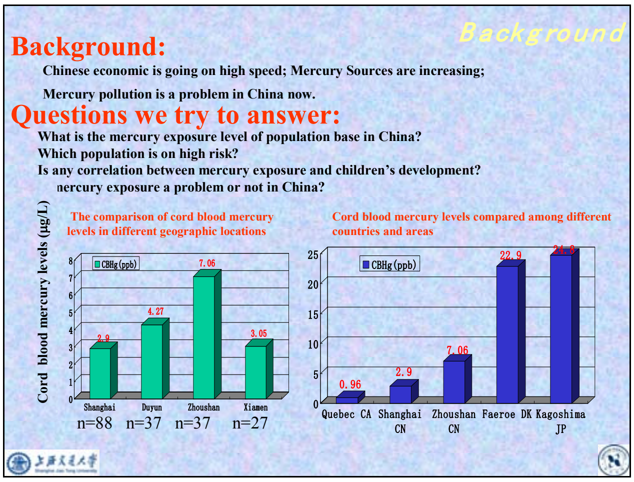
Whether prenatal exposure to mercury from contaminated seafood is associated with children's neurodevelopment has raised concern, but the outcomes were controversial. Results of studies of prenatal exposure to MeHg from seafood consumption in the Faeroe Islands have shown adverse neurodevelopmental outcomes including language, attention, memory, motor and hearing, but the longitudinal neurodevelopmental study conducted in Seychelles didn't support these outcomes. The cohort was assessed when children were 6, 19, 29, 66 and 107 months. They have detected no adverse effect on children development associated with prenatal mercury from ocean fish. In our studies, there was significantly statistical difference between MeHg and MDI, PDI neither at 3 months nor 12 months. In Zhoushan, the seafood has a much lower concentration of mercury than in other two countries and the mean concentration of Hg contained in ocean fish was 0.026μg/kg.Wherease, in Faeroe Islands whale is the main source of mercury, the mean concentration of mercury in whale meat was 1.6μg/kg.In seychelles, the mean mercury of different species of ocean fish was 0.3μg/kg, which was several tens times than that of Zhoushan. The study of Faeroe Islands found the level of maternal hair mercury in 3-10 mg/kg may put adverse effects on children neurodevelopment. WHO adopted 5 mg/kg Hg in hair as the international standard for the upper tolerable level. The mean maternal hair mercury in Zhoushan was 1.25 mg/kg, which reflects a low level mercury exposure. It's in a relatively safe range that can pose no threat to neurodevelopment. In our studies, BSID was used to assess children neurodevelopment. It may not be sensitive enough to assess potential associations between developmental outcomes and mercury dietary exposure.

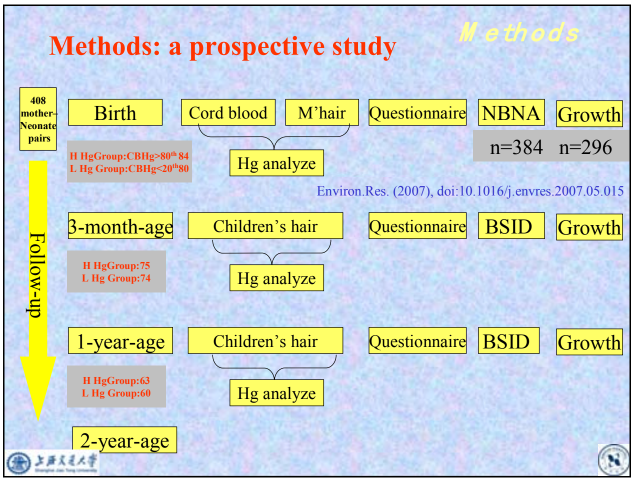
5. Conclusions

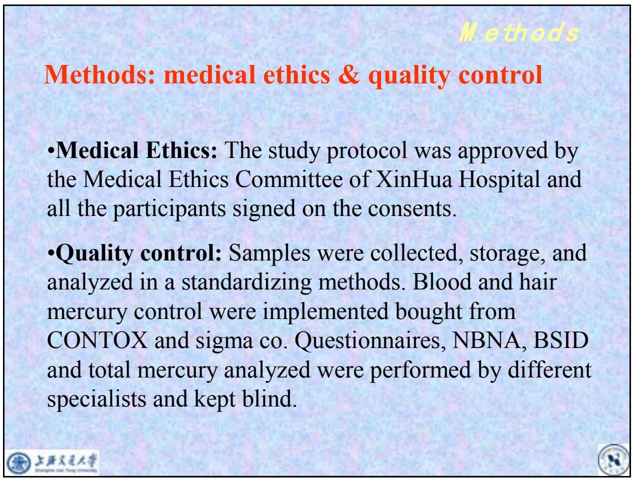
The CBHg was significantly related with hair mercury level at 3 and 12 mos. The mercury exposure level of 12-month-infant was lower than that of 3-month-infant. Prenatal low level mercury exposure had very subtle impact on infants' development.

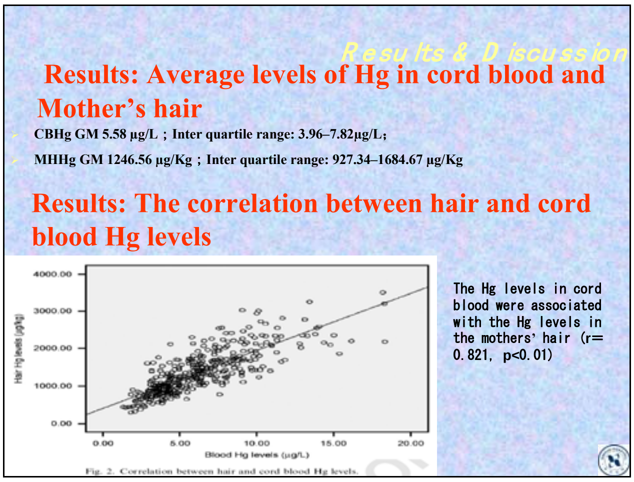
発表データ

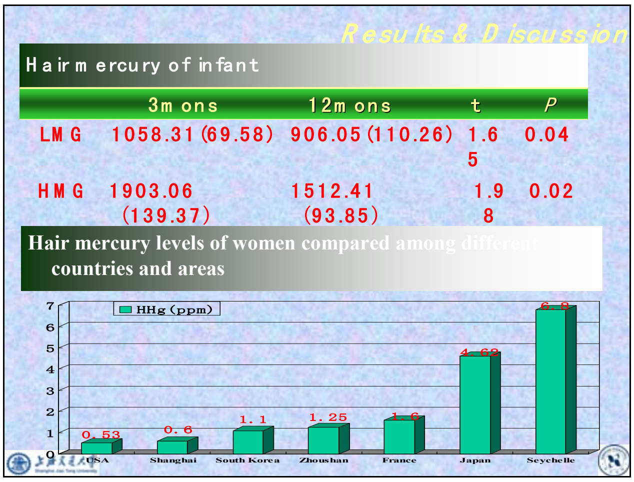

Prenatal low levels mercury exposure on infant development: a prospective study in Zhoushan Islands, China
出生前汞暴露对婴儿发育影响:舟山队列研究
Yan CH, Gao Y, Wang Y, Zhang H, Shen XM
Xinhua Hospital
上海交通大学医学院附属新华医院
Shanghai Jiao Tong University School of Medicine
Shanghai Key Laboratory of Children's Environmental Health


Background
Background:
Chinese economic is going on high speed; Mercury Sources are increasing;
Mercury pollution is a problem in China now.
Questions we try to answer:
What is the mercury exposure level of population base in China?
Which population is on high risk?
Is any correlation between mercury exposure and children's development?
nercury exposure a problem or not in China?
The comparison of cord blood mercury levels in different geographic locations
Cord blood mercury levels (μg/L)
CBHg (ppb)
2.9
4.27
7.06
3.05
Shanghai
Duyun
Zhoushan
Xiamen
n=88
n=37
n=37
n=27
Cord blood mercury levels compared among different countries and areas
CBHg (ppb)
0.96
2.9
7.06
22.9
Quebec CA
Shanghai CN
Zhoushan CN
Faeroe DK
Kagoshima JP


Methods
Methods: a prospective study
408 mother-Neonate pairs
Birth
Cord blood
M'hair
Questionnaire
NBNA
Growth
n=384
n=296
H HgGroup:CBHg>80th 84
L Hg Group:CBHg<20th 80
Hg analyze
Environ.Res. (2007), doi:10.1016/j.envres.2007.05.015
Follow-up
3-month-age
Children's hair
Questionnaire
BSID
Growth
H HgGroup:75
L Hg Group:74
Hg analyze
1-year-age
Children's hair
Questionnaire
BSID
Growth
H HgGroup:63
L Hg Group:60
Hg analyze
2-year-age

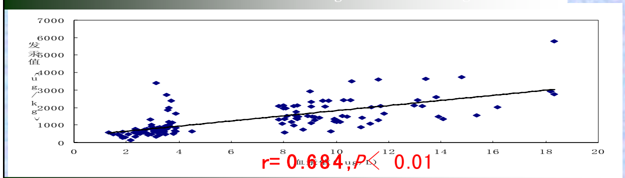

Methods
Methods: medical ethics & quality control
•Medical Ethics: The study protocol was approved by the Medical Ethics Committee of XinHua Hospital and all the participants signed on the consents.
•Quality control: Samples were collected, storage, and analyzed in a standardizing methods. Blood and hair mercury control were implemented bought from CONTOX and sigma co. Questionnaires, NBNA, BSID and total mercury analyzed were performed by different specialists and kept blind.


Results & Discussion
Results: Average levels of Hg in cord blood and Mother's hair
CBHg GM 5.58 μg/L ; Inter quartile range: 3.96–7.82μg/L;
MHHg GM 1246.56 μg/Kg ; Inter quartile range: 927.34–1684.67 μg/Kg
Results: The correlation between hair and cord blood Hg levels
Hair Hg levels (μg/kg)
Blood Hg levels (μg/L)
Fig. 2. Correlation between hair and cord blood Hg levels.
The Hg levels in cord blood were associated with the Hg levels in the mothers' hair (r=0.821, p<0.01)

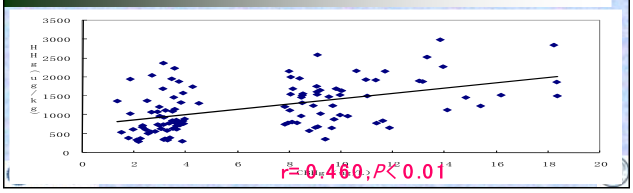

Results & Discussion
Hair mercury of infant
3mons
12mons
t
P
LMG 1058.31 (69.58) 906.05 (110.26) 1.65 0.04
HMG 1903.06 (139.37) 1512.41 (93.85) 1.98 0.02
Hair mercury levels of women compared among different countries and areas
HHg (ppm)
0.53
0.6
1.1
1.25
4.69
6.8
USA
Shanghai
South Korea
Zhoushan
France
Japan
Seychelle

Results & Discussion

Results: The correlation between 3month-hair Hg and cord blood Hg levels



Results: The correlation between 12month-hair Hg and cord blood Hg levels



Results & Discussion

Results: Mercury levels vs. different frequency of fish consumption

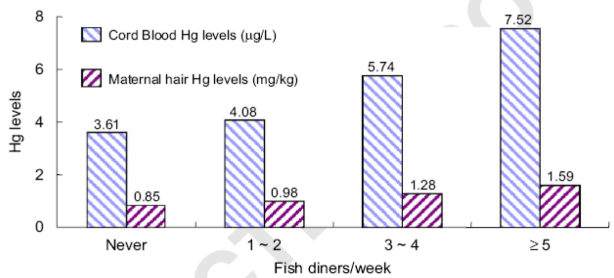


Fig. 3. Mercury level vs. different frequency of fish consumption (as main meals).

Results & Discussion

Results: Logistic regression analysis on the NBNA scores of male and female neonates

Table 2
Logistic regression analysis on the NBNA scores of male neonates

Dependent variable	Independent variable	Parameter estimate	SE	Waldχ^2	P-value	OR	95%CI of OR
Total score	Birth weight	−0.002	0.001	8.0	0.005	0.998	0.996–0.999
Behavior score	Paternal smoking	−2.521	0.621	16.473	0.000	0.080	0.024–0.272
	Cord blood Hg	0.211	0.069	9.246	0.002	1.235	1.078–1.414
Active tones	Caught a cold during first 3 months of pregnancy	1.159	0.424	7.482	0.006	3.188	1.389–7.317
Passive tones	Body height of newborns	−0.372	0.190	3.830	0.050	0.689	0.475–1.001

Table 3
Logistic regression analysis on the NBNA scores of female neonates

Dependent variable	Independent variable	Parameter estimate	SE	Waldχ^2	P-value	OR	95%CI of OR
Total score	Premature rupture of membranes	1.999	1.027	3.791	0.052	7.381	0.987–55.211
	Anemia during pregnancy	2.287	0.798	8.203	0.004	9.841	2.058–47.058
Behavior score	Caught a cold during first 3 months of pregnancy	−1.341	0.634	4.467	0.035	0.262	0.075–0.907
Active tones	Fathers were native	1.386	0.684	4.108	0.043	4.000	1.047–15.284
Passive tones	Fathers' age	0.138	0.047	8.741	0.003	1.148	1.048–1.258
	Fathers were native	1.942	0.840	5.346	0.021	6.972	1.344–36
	Paternal alcohol consumption	0.950	0.456	4.330	0.037	2.584	1.057–6.

Results & Discussion

Results: the Scores of BSID compare of both groups in 3-m-age and 1-y-age

BSID	Low Hg Group 1.34~3.98ppb	High Hg Group 8.09~18.34ppb	t value	p value
3 months	n=74	n=75		
MDI	109.01±4.16	108.32±4.23	0.497	>0.05
PDI	99.91±3.28	99.71±5.21	0.521	>0.05
12 months	n=60	n=63		
MDI	110.60±4.29	109.56±4.15	0.506	>0.05
PDI	104.06±3.28	101.70±5.21	1.104	>0.05

Results & Discussion

Results: The influencing factors of MDI、PDI at 3-month and 12-month-age with multiple linear regression analysis

variable	coefficients	Std	t value	P value	Standardize coefficients
MDI at 3 months					
Hair mercury	128.581	16.221	7.927	0.000	10.634
Head circumstance	9.577	4.534	2.112	0.037	0.169
PDI at 3 months					
Hair mercury	61.913	13.949	4.438	0.000	0.412
Gender	-279.821	124.573	-2.246	0.027	-0.209
MDI at 12 months					
haematoglobin	0.353	0.110	3.217	0.002	0.307
Age child starting stand	-3.201	1.488	-2.151	0.034	-0.210
Having pneumonia	-5.739	2.810	-2.042	-0.044	-0.197
PDI at 12 months					
Age child starting stand	-7.994	1.858	-4.302	0.000	-0.390
Fish dinners of mother	5.696	1.877	3.035	0.003	0.267
haematoglobin	0.405	0.136	2.967	0.004	0.26

Conclutions

Conclutions:

1. The mercury exposure level of population base in China is about medium level in the world.

2. Fish eating population is on high risk of mercury exposure in Zhoushan city.

3. The correlation between prenatal mercury exposure and children's development is very subtle at this level.

Methylmercury Exposure, Fish Consumption, and Cardiovascular Function in Faroese Whalingmen

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[b]*Faroese Hospital System, Tórshavn, Faroe Islands.*
[c]*Institute of Public Health, University of Southern Denmark, Odense, Denmark*

Abstract
Methylmercury (MeHg), a worldwide contaminant found in fish and seafood, has been linked to an increased risk of cardiovascular mortality. However, certain essential nutrients in fish and seafood may provide beneficial effects on brain development, and may protect against the development of heart disease, thereby possibly counteracting the adverse effect of the toxicant. The impact on the same health outcomes by two exposures originating from the same food source provides a classic example of negative confounding. We examined 42 Faroese whalingmen (aged 30-70 years) to assess possible adverse effects within a wide range of MeHg exposures from consumption of pilot whale meat. The number of fish dinners consumed per week in the last year was included as a covariate that was allowed to affect both mercury exposure and outcomes. Exposure levels were assessed from mercury analysis of toenails and whole blood obtained at the time of clinical examination, and of a hair sample collected seven years previously. Outcome measures included heart rate variability, blood pressure (BP), common carotid intima-media thickness (IMT), and brainstem auditory evoked potentials. Multiple regression and structural equation analyses were carried out to determine the confounder-adjusted effect of mercury exposure. All mercury concentrations varied widely; geometric means were 2.0 μg/g for toenails and three-fold higher for hair concentrations. The strongest associations were seen with BP and IMT, and toenail mercury was the strongest predictor. Adjustment for the benefits from fish consumption resulted in strengthened associations between mercury exposure and increased BP and IMT. The results support the notion that increased MeHg exposure from seafood promotes the development of cardiovascular disease, and that underestimation of the effects of both mercury toxicity and fish benefit will occur from the lack of mutual adjustment.

Keywords: cardiovascular physiology, confounding factors, food contamination, methylmercury, pilot whale, seafood.

1. Introduction

Methylmercury (MeHg) is a worldwide contaminant found in fish and seafood. It is a well-established neurotoxicant that can have serious adverse effects on the developing nervous system. Recent evidence has suggested that mercury from fish and seafood may promote or predispose adults to the development of heart disease. Fish, however, contains essential nutrients such as long-chain n-3 polyunsaturated fatty acids that may have beneficial effects on brain development and may prevent cardiovascular disease, thereby counteracting the adverse effects of methylmercury[1]. This situation constitutes a classic example of negative confounding – the factors that affect the same outcome are associated with each other, as they derive from the same food items; that is, fish and seafood[2].

To explore the effects of MeHg on cardiovascular functions with the adjustment for the benefits from fish consumption, we examined 42 male members of the whaling society in the Faroe Islands. This Nordic fishing community exhibits a wide range of MeHg exposure that primarily originates from consumption of pilot whale meat; other types of seafood contain lower MeHg concentrations.

2. Subjects and Methods

Fifty-four whalingmen participated in the exposure and clinical examinations, 42 of which were between 30 and 70 years of age. The Faroese Ethical Review Committee and the Institutional Review Board at the Harvard School of Public Health approved the study protocol, and we obtained written informed consent from all participants. Details of the study are described elsewhere[3].

To ascertain long-term exposures to MeHg from food, we analyzed whole blood, toenails, and a hair sample collected 7 years before for mercury. Outcome measures included heart rate variability[4], blood pressure (BP, systolic and diastolic), intima-media thickness (IMT) of the carotid arteries[5], and brainstem auditory evoked potentials[4,6]. Characteristics of the subjects included in the analyses were age, body mass index, smoking history, and weekly alcohol consumption. The number of fish dinners consumed per week in the last year was included as a covariate that was allowed to affect both mercury exposure and outcomes. Because of the availability of several exposure parameters and several outcome variables, standard regression analysis with confounder adjustment was complemented by structural equation models (SEM)[7,8] to assess the association between an integrated set of biomarkers of mercury exposure on the one hand, and sets of cardiovascular and neurophysiologic outcomes on the other.

3. Results and Discussion

All exposure biomarkers showed relatively wide ranges. The toenail mercury concentrations had a geometric mean

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of 2.0 μg/g, and the hair concentrations averaged about 3-fold higher. Mercury concentrations in hair samples taken 7 years earlier were higher than the levels in the current hair samples. Among the four exposure biomarkers, mercury in toenails showed the closest correlation with hair mercury levels. The mean IMT was highly correlated with the maximal and minimal IMT measures (r=0.92 and 0.94 respectively). Similarly, the systolic and diastolic BPs correlated well (r=0.79), as did the components of heart rate variability.

Mercury concentrations in current hair and whole-blood samples were highly correlated (r=0.94), and the former was therefore disregarded. To obtain an SEM consisting of exposure variables with independent error terms, we included the results only for toenails, blood, and hair from 7 years previously. This model showed that toenail measurement had the smallest error component with the highest correlation with the estimated latent exposure (0.98, compared with 0.83 for blood and 0.46 for hair). High correlations among related measures within this small sample size limited the number of outcome variables that could be included in each of the latent variables. For comparison, results were calculated both for major individual effect variables and for the latent variables. For BP and IMT, tendencies were similar for the individual exposure parameters and the latent exposure variable, thus supporting a causal linkage.

Adjustment for the benefits from fish consumption resulted in strengthened associations between mercury exposure and increased BP and IMT outcome measures. One SD increase in nail Hg exposure was associated with 41.9% SD change (95% CI, 14.2-69.9) in mean IMT with fish adjustment, and 33.8% SD change (95% CI, 7.56-60.5) without fish adjustment. A doubling in Hg exposure was associated with a 2.92 mmHg increase (95% CI, 0.07-5.76) in diastolic blood pressure with adjustment for fish, and 2.68 (95% CI, 0.10-5.27) without it.

Our findings suggest that MeHg may promote development of cardiovascular disease, as indicated by increased in BP and in IMT. Brainstem evoked potentials latencies showed slight delays associated with MeHg exposure, with wide confidence limits, whereas effects on heart rate variability were equivocal. The results also suggest that underestimation of the effects of mercury toxicity and fish benefit may occur from the lack of mutual adjustment. This issue of negative confounding can distort the true association between the exposure and the toxic-effect outcome. Future studies should assess both beneficial and adverse effects of fish and seafood intake at the same time using reliable exposure parameters to separate the opposite impacts on the outcomes. Given this inherent bias in observational studies, regulatory agencies should reconsider current dietary advice in order to provide better guidance to consumers in making prudent choices to maintain a nutritious diet with fish and seafood that is low in mercury concentrations.

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発表データ

Methylmercury Exposure, Fish Consumption, and Cardiovascular Function in Faroese Whalingmen

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Harvard School of Public Health
Pal Weihe
Faroese Hospital System

(An extension of Choi et al. 2009, Environ Health Perspect 117:367-372)

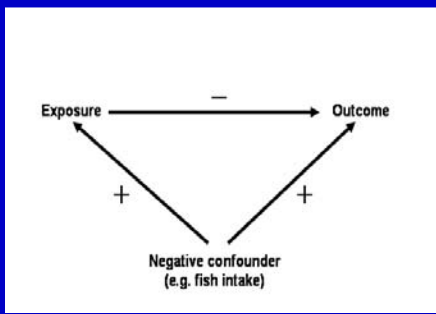
Methylmercury

- Found in seafood and freshwater fish
- A neurotoxicant that can have adverse effects on the developing nervous system and cardiovascular health

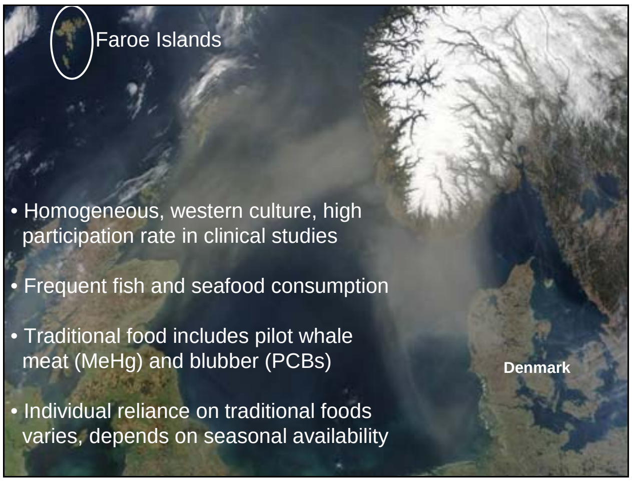
Cardiovascular Function

- Mercury from fish and seafood *may* promote or predispose to the development of heart disease in some studies
- Elevated hair and toenail mercury concentration was associated with
  - Increased risk of coronary heart disease (Salonen et al., 1995)
  - Accelerated progression of carotid atherosclerosis (Salonen et al., 2000)
  - Higher risk of myocardial infarction (Guallar et al. 2002, Yoshizawa et al. 2002)

Negative Confounding



(Choi et al., 2008)



- Homogeneous, western culture, high participation rate in clinical studies
- Frequent fish and seafood consumption
- Traditional food includes pilot whale meat (MeHg) and blubber (PCBs)
- Individual reliance on traditional foods varies, depends on seasonal availability

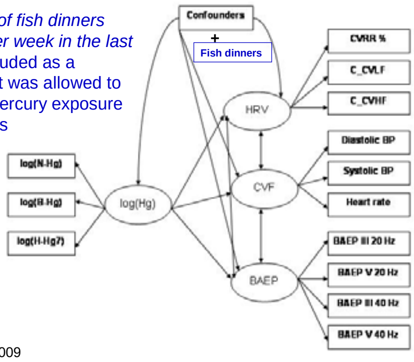

- **42 male members of the Faroese whaling society (30-70 years of age)**
- **They organize and participate in the whale drives and receive a larger share of whale meat and blubber**
- **Hair, blood and toenail samples, and clinical examination data were collected**

Distribution of mercury and PCB concentrations

Exposure biomarker	Geometric mean	Interquartile range	Total range	Correlation with toenail Hg
Toenail (μ g/g)	2.04	1.35-3.29	0.14-8.26	(1)
Blood (μ g/L)	29.5	18.7-46.1	5.19-128.4	0.60
Hair (μ g/g)				
Current	7.31	4.52-13.4	0.92-46.0	0.70
7 years ago	13.9	9.80-21.9	4.80-43.7	0.56
Serum PCB (μ g/g lipid)	10.8	6.6-16.8	1.13-42.4	0.54

In a structural equation model, the latent exposure variable is optimized based on the three exposure predictors, confounders, and latent effect variables

The number of fish dinners consumed per week in the last year was included as a covariate that was allowed to affect both mercury exposure and outcomes



Choi et al., 2009

Change in cardiovascular outcomes [%SD and 95%CI] associated with 1 SD increase in Hg exposure in a cohort of Faroese Whaling men (30-70 years of age)

Outcomes	Exposure Indicators			
	Blood Hg	Nail Hg	Hair Hg (7 yrs ago)	Latent Hg
Latent CVF	23.9 (-12.1,60.1)	37.1 (0.46,74.3)**	14.5 (-29.3,58)	38.0 (-5.6,81.2)*
Systolic BP	**37.5 (5.12,69.9)****	23.3 (-10.4,56.1)	22.1 (-13.7,58.3)	33.8 (-7.16,74.6)
Diastolic BP	**33.2 (3.15,62.9)****	**30.9 (0.72,61.5)****	14.1 (-18.9,46.6)	**32.4 (-2.58,67.2)***
Heart rate	8.9 (-23.7,41.2)	13.3 (-19.4,45.7)	17.6 (-16.9,52.6)	24.0 (-6.76,54.1)
IMT				
Mean	25.0 (-5.27,55.3)	**41.9 (14.2,69.6)****	**33.6(3.64,63.3)****	**29.0 (-3.94,61.9)***
Maximum	16.8 (-16.0,49.7)	**34.8 (3.99,65.6)****	**34.4(2.50,66.0)** **	24.7 (-10.5,59.8)
Minimum	23.0 (-6.77,52.8)	**39.0 (11.7,66.6)****	**29.4 (-0.29,59.0)***	24.6 (-7.71,56.9)

Change in cardiovascular outcomes [%SD and 95%CI] associated with 1 SD increase in nail Hg exposure *With and without fish adjustment*

Outcome	Exposure Indicator (Nail Hg)	
	With fish adjustment	Without fish adjustment
Latent CVF	***37.1 (0.46, 74.3)*****	***34.2 (-0.75, 69.4)****
Systolic BP	23.3 (-10.4, 56.1)	26.6 (-4.47, 57.3)
Diastolic BP	**30.9 (0.72, 61.5)****	**29.4 (1.06, 58.0)****
Heart rate	13.3 (-19.4, 45.7)	15.9 (-16.6, 48.8)
IMT		
Mean	**41.9 (14.2, 69.6)****	**33.8 (7.56, 60.5)****
Maximum	**34.8 (3.99, 65.6)****	**26.4 (-2.90, 55.4)***
Minimum	**39.0 (11.7, 66.6)****	**29.8 (3.31, 56.3)****

Change in blood pressure associated with a doubling in mercury exposure

With fish adjustment

Blood Pressure (mmHg)	Exposure Indicators		
	Blood Hg	Nail Hg	Hair Hg (7 yrs ago)
Systolic	**5.71 (0.78, 10.6)****	3.81 (-1.73, 9.35)	5.15 (-3.17,13.5)
Diastolic	**2.91 (0.28, 5.55)****	**2.92 (0.07, 5.76)****	1.89 (-2.58, 6.36)

Without fish adjustment

Blood Pressure (mmHg)	Exposure Indicators		
	Blood Hg	Nail Hg	Hair Hg (7 yrs ago)
Systolic	**5.49 (0.65, 10.3)****	4.40 (-0.74, 9.55)	5.34 (-2.29,13.0)
Diastolic	**2.50 (0.01, 5.02)****	**2.68 (0.10, 5.27)****	1.34 (-2.61, 5.34)

Conclusions

- Increased methylmercury exposure promotes the development of cardiovascular disease
- The strongest associations were seen with blood pressure and common carotid intima-media thickness, with toenail mercury as the strongest predictor
- The relationship between the benefits and risks associated with fish and seafood consumption is a classic example of negative confounding
- Substantial underestimation of mercury toxicity and fish benefits will result from a lack of confounder adjustment
- Adjustment for the benefits from fish consumption resulted in strengthened associations

Maternal fish intake during pregnancy, blood mercury, and child cognition at age 3 years in a US cohort

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Abstract

The balance of contaminant risk and nutritional benefit from maternal prenatal fish consumption for child cognitive development is not known. Using data from a prospective cohort study of 341 mother-child pairs, authors studied associations of maternal 2nd trimester fish intake and erythrocyte mercury levels with child age 3 year scores on the Peabody Picture Vocabulary Test (PPVT) and Wide-Range Assessment of Visual Motor Abilities (WRAVMA). Mean maternal total fish intake was 1.5 (SD 1.4) servings/month, and 40 (12%) of mothers consumed > 2 weekly fish servings. Mean (SD) maternal mercury was 3.8 (3.8) ng/g. After adjustment using multivariable linear regression, higher fish intake was associated with better child cognitive test performance, and higher mercury levels with poorer test scores. Associations strengthened with inclusion of both fish and mercury: effect estimates (95% CI) for fish intake > 2 servings/week vs. never were 2.2 (-2.6, 7.0) for PPVT and 6.4 (2.0, 10.8) for WRAVMA; and for mercury in the top decile, -4.5 (-8.5, -0.4) for PPVT and -4.6 (-8.3, -0.9) for WRAVMA. Fish consumption <= 2 weekly servings was not associated with a benefit. Dietary recommendations for pregnant women should incorporate the nutritional benefits as well as the risks of fish intake.

Keywords: Pregnancy, Fishes, Mercury, Child Development, n-3 fatty acids

Introduction

Fish and other seafood may contain beneficial nutrients such as n-3 fatty acids as well as harmful contaminants such as mercury. The overall effect of fish consumption during pregnancy, incorporating the risks as well as the benefits, remains uncertain. A few recent studies, as well as a re-analysis of data from the Faroe Islands cohort, have found that on balance, maternal fish intake is associated with improved child cognitive development [1-3]. In the present study, we used prospectively collected information on maternal diet and mercury levels during pregnancy to examine the risks and benefits of maternal prenatal fish intake on child development at age 3 years.

Methods

Subjects were participants in Project Viva, a prospective pre-birth cohort study. We selected women with an available maternal hair sample (n=98), with preterm or SGA birth (n= 45, and a random sample of 198 of the remaining 753. At the second trimester study visit, participants completed a semiquantitative food frequency questionnaire. At this visit, we also obtained blood specimens. We performed total mercury assays of maternal erythrocytes using the Direct Mercury Analyzer 80.

Trained research assistants administered two cognitive tests to children at age 3 years. The *Peabody Picture Vocabulary Test* (PPVT) evaluates receptive vocabulary among children aged 2½ years and older. Mothers also completed the PPVT. The *Wide Range Assessment of Visual Motor Ability* (WRAVMA) evaluates three domains of visual motor development: visual-spatial (matching test), visual-motor (drawing test), and fine motor skills (pegboard test), which are used to generate a total standard score. We used multivariate linear regression to examine associations of participant characteristics and exposures of interest with child cognitive test scores. We categorized fish intake according to current US guidelines [4] as never, <= 2, and > 2 servings per week. We categorized mercury at the top decile or below.

Results and Discussion

Maternal fish intake was directly correlated with erythrocyte total mercury (spearman r = 0.42, p < 0.0001), with an unadjusted increase of 0.94 (95 percent confidence interval [CI]: 0.66, 1.21) ng/g mercury for each weekly fish serving. The likelihood of being in the top decile of erythrocyte mercury was 2 percent in those who never consumed fish but 23 percent in those who consumed fish more than twice weekly (table 1). After adjustment for parent and child characteristics, maternal fish intake > 2 weekly servings, compared with never, was directly associated with higher child WRAVMA drawing and total scores (table 3). Associations strengthened with adjustment for mercury levels, with the largest effects seen for the WRAVMA drawing (6.4, 95 percent CI: 2.1, 10.7) and total (6.4, 95 percent CI: 2.0, 10.8) scores, and generally positive associations also seen on the other tests. Higher maternal erythrocyte mercury levels were associated with worse child test performance, with stronger associations after adjustment for fish intake (table 4). We observed the strongest adverse associations of mercury levels with the PPVT (-4.5, 95 percent CI: -8.5, -0.4), WRAVMA matching (-6.0, 95 percent CI: -10.9, -1.1), and WRAVMA total (-4.6, 95 percent CI: -8.3, -0.9) tests.

In this US cohort with moderate fish consumption, pregnant women who ate more fish had higher erythrocyte mercury levels. Among their children, higher prenatal mercury exposure was associated with lower developmental test scores at age 3 years. Nevertheless, we observed no overall adverse effect upon child development with higher maternal fish intake. Rather, maternal fish intake more than twice a week was associated with improved performance on tests of language and visual motor skills. We observed associations of mercury levels with child cognition at exposure levels substantially lower than in populations previously studied. Our findings suggest that no lower threshold exists for the adverse effects of prenatal mercury exposure.

Our finding that the benefit of fish intake is strengthened with adjustment for mercury levels suggests that if mercury contamination were not present, the cognitive benefits of fish intake would be greater. Maternal consumption of fish lower in mercury and reduced environmental mercury contamination would allow for stronger benefits of fish intake. Recommendations for fish consumption during pregnancy should take into account the nutritional benefits of fish as well as the potential harms from mercury exposure.

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発表データ

Maternal fish intake during pregnancy, blood mercury, and child cognition at age 3 years in a US cohort

DACP

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Harvard Medical School and Harvard Pilgrim Health Care

Study population

- 2128 births
- 1585 enrolled through age 3 years
- 896 with exposure & outcome data
- Funding for 341 mercury assays
  - Hair sample available (n=98)
  - Preterm or SGA (n=45)
  - Random sample (n=198)

Biosample collection and assay

- Maternal 2nd trimester blood (26-28 weeks)
  - Collected in tube with EDTA
  - Separated into plasma and RBC
  - Stored at -70 ºC
- Mercury assay of packed RBC
  - Sample in-homogeneity - cell lysis and centrifugation
  - Total mercury assayed using Direct Mercury Analyzer 80

Maternal diet

- Self-administered, optically-scanned semi-quantitative food frequency questionnaire (FFQ)
- 2nd trimester diet
  - Administered at 26-28 weeks gestation
  - Asked about diet "in the past 3 months"
- Harvard nutrient database used to estimate elongated n-3 fatty acid intake (DHA, EPA)
- Measured maternal blood DHA, EPA

Child age 3 year cognitive outcomes

- PPVT – language
  - Receptive vocabulary
  - Correlated with WISC-III verbal and full-scale IQ (r~0.90)
- WRAVMA – visual motor ability
  - Matching test (visual spatial)
  - Drawing test (visual motor)
  - Pegboard (fine motor)
  - Modestly correlated with IQ (r~0.60)
- Both standardized to have mean 100 and SD 15

Analysis

- Fish intake according to current guidelines
  - Never, <= 2, > 2 weekly servings
- Mercury dichotomized at top decile vs. below
  - Corresponds with 1.2 ppm (~RfD) of maternal hair in our population
- Outcomes continuous
- Multivariable linear regression
  - Adjusted for parent and child characteristics

Higher Hg with higher fish intake

No difference in other characteristics

	Fish intake		
N=341	Never (14%)	<=2 svg/wk (74%)	>2 svg/wk (12%)
RBC mercury (ng/g)	1.9 (2.3)	3.9 (3.8)	5.6 (4.5)
RBC mercury top decile	2%	10%	23%
Hair mercury (ppm) (n=98)	0.28 (0.31)	0.56 (0.47)	0.80 (0.61)
DHA+EPA from fish (mg/d)	0 (0)	122 (97)	318 (160)
DHA+EPA total (mg/d)	22 (77)	148 (142)	301 (159)
Age (y)	31.7 (4.8)	32.8 (4.6)	32.3 (4.7)
White	85%	82%	85%
College graduate	82%	80%	83%
Breastfeeding (mos)	7.2 (4.4)	7.0 (4.5)	6.8 (4.7)

Maternal mercury and child cognition

Child test score	Age and sex	MV	MV + fish
PPVT			
Hg top decile	-5.3 (-10.1, -0.5)	-4.0 (-8.0, 0.0)	-4.5 (-8.5, -0.4)
Hg < 90th %ile	Referent	Referent	Referent
WRAVMA total			
Hg top decile	-3.4 (-7.0, 0.2)	-3.5 (-7.2, 0.2)	-4.6 (-8.3, -0.9)
Hg < 90th %ile	Referent	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Maternal fish intake and child cognition

Child Test Score	Age and sex	MV	MV + Hg
PPVT			
Fish > 2x/wk	-1.5 (-7.3, 4.4)	1.2 (-3.5, 6.0)	2.2 (-2.6, 7.0)
Fish <= 2x/wk	-2.2 (-6.5, 2.2)	-2.1 (-5.7, 1.4)	-1.8 (-5.4, 1.8)
Fish never	Referent	Referent	Referent
WRAVMA total			
Fish > 2x/wk	3.7 (-0.7, 8.1)	5.3 (0.6, 9.6)	6.4 (2.0, 10.8)
Fish <= 2x/wk	0.7 (-2.5, 4.0)	1.1 (-2.2, 4.4)	1.5 (-1.8, 4.7)
Fish never	Referent	Referent	Referent

*MV adjustment = Child: fetal growth, gestation length, breastfeeding duration, birth order, language; Maternal: PPVT score, age, BMI, race/ethnicity, education, marital status, smoking; Paternal: education.

Limitations

- No measure of home stimulation
- Small sample
- May not be representative of larger US population
- Only a few outcomes
- Limited information about specific fish types
- No measure of PCB's/other toxicants

Conclusions

- Higher fish intake – higher mercury
- Higher mercury – lower age 3 scores
  - Stronger after adjustment for fish
- Higher fish intake – higher age 3 scores
  - Especially after adjustment for mercury
- Results generally consistent across all outcomes tested
- Extends our earlier findings

Conclusions (con't)

- Pregnant women should continue to eat low Hg fish
- Future studies should include measures of both fish and Hg
- Recommendations for fish consumption during pregnancy should emphasize the nutritional benefits of fish as well as toxicant risks

Omega-3 Fatty Acids and Methylmercury in Diet: Sources, Effects, and Public Health Considerations

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Abstract

Fish and shellfish contain both methylmercury and n-3 polyunsaturated fatty acids (n-3 PUFAs) or omega-3 fatty acids. Methylmercury is a neurotoxin that at high exposures produces devastating effects on the developing nervous system while specific n-3 PUFAs are important structural components of nerve and retina tissue development. Balancing nutritional requirements for n-3 PUFAs and risks associated with high levels of methylmercury exposure is therefore an important publish health concern for fish-eating populations. Across species, EPA and DHA in specific fish and shellfish species vary by more than a factor of 10, while methylmercury can differ by 20-to-30 fold. Fish that are highest in omega-3 fatty acids are not necessarily high in methylmercury and some fish that are high in methylmercury do not contain substantial amounts of the omega-3 fatty acids. Thus, it is possible to obtain all nutritional requirements for n-3 PUFAs from low mercury fish and shellfish. Estimates of nutritional requirements for n-3 PUFAs range between 100-2000 mg/day. Benefits from n-3 PUFAs in fish beyond 2000 mg/day are therefore unlikely, while risks associated with methylmercury exposure will continue to increase at higher consumption levels. Knowing which fish and shellfish have the most health protective ratios of omega-3 fatty acids and are the lowest in methylmercury will help people chose fish that are the most protective of human health. In addition, humans can synthesize some of the essential n-3 PUFAs (Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) from other dietary fatty acids precursors found in foods such as soybean and flax oils, but it is not clear if the rate of synthesis is rapid enough to meet the needs of the developing fetal nervous system. A range of products enriched in EPA and DHA such as algae, enriched eggs and cereals are increasingly available to supplement dietary intakes of n-3 PUFAs. These alternatives appear to have similar bioavailability and uptake efficiencies as fish sources.

Keywords: methylmercury, omega-3 fatty acids, n-3 polyunsaturated fatty acids, eicosapentaenoic acid, EPA, decosahexaenoic acid, DHA, fish, blood mercury, diet.

1. Inroduction

A public health goal is to identify diets that provide needed nutrients in a balance that is optimal for health, while avoiding chemicals that are known to be toxic (for example, methylmercury and lead). Exposure to methylmercury is associated with the type and quantity of fish consumed by individuals (Mahaffey et al., 2004). Fatty acids with a double bond between the third and fourth carbons are called n-3 polyunsaturated (multiple double bonds) fatty acids (n-3 PUFAs). These are important because they are a part of structural membrane lipids, particularly in nerve tissue and the retina. This paper discusses options for meeting nutritional requirements for n-3 PUFAs while minimizing exposure to methylmercury in fish, including a review of non-fish sources of omega-3 fatty acids.

2. Synthesis of EPA and DHA from Precursors

Humans can synthesize many fatty acids from other energy sources such as carbohydrates, but do not have the enzymes needed to place a double bond at certain positions in the structure of some fatty acids. Two fatty acids especially important for human neurodevelopment are eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). Humans can synthesize omega-3 fatty acids from the chemical precursor, α-linolenic acid (ALA|) found in foods like flax seed and soybean oil (Burdge and Calder, 2005, NAS/NRC, 2005) or can obtain preformed EPA and DHA from dietary sources such as fish and shellfish. Synthesis of EPA and DHA from α-linolenic acid is organ specific, varies substantially from person to person, is likely affected by conditions of disease (for example, liver toxicity), and is associated with exposure to environmental contaminants, drugs, and other nutrients (Rapoport, 2008).

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Women convert ALA to EPA and DHA more readily than men (Extier et al., 2009). Ability of humans to synthesize sufficient DHA from precursors for optimal development of fetal brain and cardiovascular protection remains uncertain.

3. Recommended Intake of Pre-formed EPA and DHA

Expert groups' recommendations for inclusion of pre-formed EPA and DHA in the human diet range from 100 milligrams/day to 1600 milligrams/day (Bϑzard et al., 1994; Gao et al., 2009). Recommended intake is about 400 milligrams to 600 milligrams/day for prevention of cardiovascular disease. In the United States, recommended intakes are 1600 milligrams/day for men and 1100 milligrams/day for women for both neurodevelopmental and cardiovascular protection. Dietary DHA results in a dose-dependent, saturable increase in plasma DHA concentration with modest increases in EPA concentrations. Thus, above DHA doses of approximately 2,000 milligrams/day, which result in near maximal increases in plasma DHA (Arterburn et al., 2006), benefits from omega-3 fatty acid intakes are likely negligible.

4.Sources of Pre-formed EPA and DHA

Non-fish sources of pre-formed EPA and DHA include: algae, enriched eggs and milk, additional enriched products not traditionally considered sources of the omega-3 fatty acids, and food supplements such as fish oil (Barcel-Coblijn et al., 2008; Strijbosch et al., 2008). Algae have the enzyme systems to synthesize EPA and DHA and are responsible for more than half the production of omega-3 fatty acids at the base of the food chain (Harwood and Guschina, 2009). In addition, biotechnology has been used to produce micro algae that are rich in EPA and DHA (e.g., www.Martek.com). Hens fed special omega-3 enriched diets produce eggs containing between 100 milligrams to more than 500 milligrams of the omega-3 fatty acids per 50 gram egg (Herber and Van Elswyk, 1996; Meyer et al., 2003). Free-range or non-caged chickens often obtain diets that increase the omega-3 content of their eggs. Poultry meat may also be a source of omega-3 fatty acids (Simonpoulos, 2000). Omega-3 fatty acids from these sources are absorbed and utilized by humans with the same efficiency as fish sources (Arterburn et al., 2008).

5. Fish and Shellfish

Some fish species are high in omega-3 fatty acids and others are high in methylmercury (Mahaffey, 2004; Mahaffey et al., 2008; Sunderland, 2007). The amount of methylmercury in fish on the trophic level of the fish/shellfish species. Although both EPA and methylmercury generally increase at higher trophic levels in the planktonic food web, the magnitude of bioaccumulation is much greater for methylmercury. The fat content of specific fish species is moderately predictive of the omega-3 content with certain fatty fish species (especially salmon, mackerel, sardines, herring) being high in omega-3 fatty acids but is not correlated with methylmercury concentrations. Some species that are low in fat (especially shrimp and trout) are also good sources of omega-3 fatty acids.

6. Conclusions

Additional information is needed on quantities of omega-3 fatty acids (EPA, and especially DHA) that can be synthesized from ALA through women's metabolism. Because the ratio of omega-3 fatty acids and methylmercury concentration within individual fish and shellfish species varies considerably, it is possible to chose fish species that are both high in omega-3 fatty acids and low in mercury. Although methylmercury exposure is closely linked with the amount and species of fish eaten, there are non-fish sources of the omega-3 fatty acids. These include: algae, marine oils, products enriched with specific omega-3 fatty acids, and various meat and poultry products from animals fed diets that provide nutrients from diverse sources. A diet that enough omega-3 fatty acids, but avoids methylmercury from fish remains a goal. The solution requires dietary strategies, public health communication, and pollution control.

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発表データ

Methylmercury and Omega-3 Fatty Acids: Co-occurrence of Dietary Sources and the Role of Fish and Shellfish

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1

Omega-3 Fatty Acids

- Fatty acids contain carbon, oxygen, and hydrogen in repeating groups of –$(CH_2)n$ – with a methyl (CH_3) group on one end and a carboxyl (-COOH) group on the other end of the chain.
- Fatty acids with a double bond between the carbon atoms (-C=C-) have to be supplied in the diet because humans cannot synthesize them.

Alpha-linolenic (18:3 omega 3)
CH_3-CH_2-CH=CH-CH_2CH=CH-CH_2-CH=CH-$(CH_2)_7$-COOH

Used to synthesize:
Eicosapentaenoic or EPA (20:5 omega 3),
Docospentaenoic (22:5 omega 3) or DPA and
Docosahexaenoic (22:6 omega 3) or DHA
CH_3-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-$(CH_2)_2$-COOH

2

Human Capacity to Synthesize EPA and DHA from ά Linolenic Acid

- If alpha linolenic is in the diet humans can make some EPA and DHA. Adult males seem to form less than 10% of the amount that is needed.
- *Women, especially during pregnancy, are able to form EPA and DHA at a higher rate because of the effects of estrogens.*
- Fetus depends on transfer of EPA and DHA from the mother - Both are important to optimal neurological status during development.

3

Dietary Sources of Omega-3s

- Algae – basic source.
- *Fish, shellfish, and marine mammals are the usual sources, but depend on algae for basic synthesis.*
- Other animals (chickens, beef) can be a source of omega-3 fatty acids if these animals are grown "free range" or are able to graze in the open.
- *Special diets fed to chickens can produce eggs containing more than 600 mg of omega-3 fatty acids per each 100 gram egg.*
- Food supplements such as fish oil or supplements based on algae.
- *Biotechnologically produced omega-3 fatty acids; e.g. from microalgae.*

4

Omega-3 Fatty Acids in Eggs

- Hens fed a special diet containing flaxseed, canola oil, sea algae or other omega-3 rich products.
- *One egg provides 100 mg to 660 mg (Christopher Eggs) compared with ~ 40 mg/egg in traditional eggs. An egg weighs ~ 50 grams. 200 mg to 1320 mg/100 gram portion.*
- Yearly per capita egg consumption of eggs in 2001 was 252 eggs (Pickering, 2003) in the United States.
- *"Designer" eggs are ~ 5% of the egg market (Hander, 2001) in the United States. Omega-3 eggs are likely 2% or 3% of the total egg market, but firm figures are not readily available.*
- Two eggs can supply the recommended ~ 1300 mg omega-3 fatty acids.
- *Cost in US $ is about $.30/egg or ~ $0.60 for two eggs.*

5

The Balance: Omega-3s and Methylmercury in Seafood

- Recommendations of 1600 milligrams of omega-3 fatty acids for men and 1100 milligrams of omega-3 fatty acids for women (US NAS/NRC Dietary Recommendations) = average 1350 milligrams/day.
- Reference dose for CH_3Hg based on fish consuming cohorts.
- *Little association between* CH_3Hg *in fish and DHA in fish.*
- Can have nutritional benefit from fish and still have low CH_3Hg intake.

6

Omega-3 Content of Fish & Shellfish Vary Widely - Virtually All Contain Methylmercury

Fish Species	EPA + DHA Mg/ 100 gms of Fish	Hg µ g/g of Fish	Gms of Fish Containing 1350 mg EPA + DHA	Hg intake for 1350 mg EPA + DHA in this fish species.	µ g Hg per kg bw for a 70 kg adult
Mackerel	1790	0.087	75	6.5	0.09*
Salmon	1590	0.035	85	3.0	0.04*
Swordfish	580	0.950	230	220	3.2
Cod	240	0.121	560	68	0.97

8

Omega-3 Content of Fish & Shellfish Vary Widely - Virtually All Contain Methylmercury

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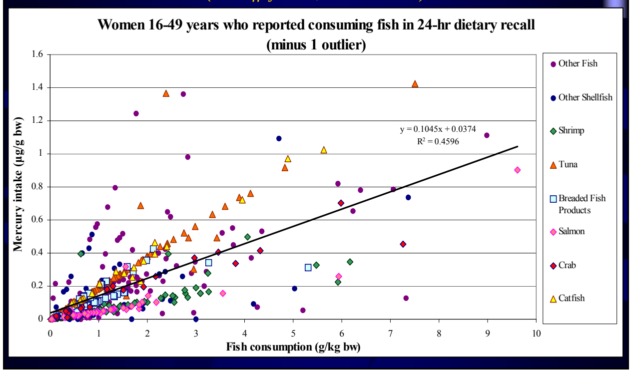
Cod	240	0.121	560	68	0.97

8

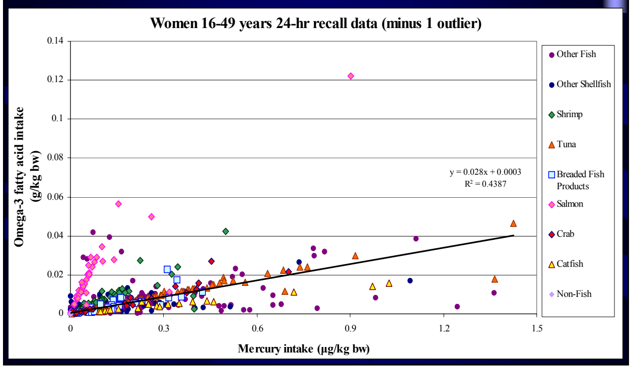
NHANES 1999-2002

Correlation between Total Fish Intake and Mercury Intake, both normed to body weight (Pearson Correlation R=0.68, p<0.001, n=509).
(Mahaffey et al., Env Res 2008)



NHANES 1999-2002

Omega-3 Fatty Acid (EPA + DHA) and Mercury Intake from Fish (Pearson Correlation R=0.66, p<0.001, n=3,614).
(Mahaffey et al., Env Res 2008)



Alternatives

- Pollution control – the most important solution. But may be a very long term solution.
- *Use of algae.*
- Use of biotechnology.
- *Use of diet modification to increase the oemga-3 fatty acids in other non-fish foods.*
- Use of food enrichment with EPA and DHA. In US approximately 100 food products have DHA added to them.

11

Important Data Needs

- More quantitative data on human ability to synthesize EPA and DHA from ά-linolenic acid.
- *More information on which species of fish are consumed in individual countries.*
- More data on the EPA and DHA concentrations of specific fish species.

12

Balancing the risk of methylmercury and benefits of n-3 polyunsaturated fatty acids exposure from fish consumption

Concluding Remarks

Laurie Hing Man Chan, Ph.D.

Professor and BC Leadership Chair, Community Health Sciences Program, University of Northern British Columbia

The session brought together speakers from Canada, China, Japan and the United States and with over 100 participants from all over the world. The nutritional benefits of fish consumption and potential risks were presented based on results from different studies across the world. Over the last ten years, there had been conflicting results reported from the two major cohort studies conducted in Faroe Island and the Seychelles over whether methylmercury (MeHg) had significant effects on child development. A recent report from the Seychelles study have shown that adverse effects of MeHg were uncovered after adjusting for the beneficial effects of long chain polyunsaturated fatty acids (Strain et al, 2008). Therefore, the current state of knowledge indicates that while the nutritional benefits of fish consumption are significant, negative effects on child development can be observed with increasing MeHg exposure.

Concentration of Hg in hair samples have been commonly used as bioindicator for exposure. The mean concentrations in different studied population ranged from 0.6 ppm among Koreans in the US to 2.47 ppm in a Japanese study. All the reports indicate that it is not the total fish consumption that is the main determining factor for high Hg exposure but the kind of fish consumed, i.e. ocean going fish that are at the higher trophic level such as tilefish, swordfish shark, tuna, and king mackerel, that is important. While the development of benchmark dose or guideline levels are useful for risk management by the public health agencies, the different methods and approaches used by different regulatory agencies in different countries may cause confusions for the public. Scientists and public health professionals will need to collaborate to clarify the rationale behind the risk management approaches adopted in different jurisdiction and countries. In countries where a significant percentage of population had exposure higher than the guideline levels, the relevant public health officials should consider public education by promoting: 1) consumption of non-predatory fish species; 2) consumption of fish species of smaller size; and 3) reduction of fish intake among high consumers (WHO, 2008). In order to maximize the nutritional benefits from fish consumption by consuming 2 servings of fish or about 0.4 kg of fish per week, fish species that have Hg concentrations of less than 0.2 ppm or less should be preferred. They include species such as salmon, oysters, rainbow trout, pollock, halibut, scallops, clams, canned light tuna, and cod etc. (FNB, 2007). There are some developed tools such as a software that will allow consumers to choose fish species that will optimize the balance between the intake of macro/micro nutrients and chemical contaminants presented by Schumacher M et al at the poster session.

Fish is an invaluable resources in many countries and about 20% of the world's population derives one-fifth of its animal protein from fish (WHO, 2009). It is important to communicate the risk to the public without scaring them to the point that they would stop eating fish altogether. A detailed dietary advice on locally relevant fish species need to be developed for targeted population within jurisdiction. It is our hope that this on-going international collaboration in scientific research can generate results that can be used effectively in promoting healthy diet and good health.

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発表データ

Balancing the risk of methylmercury and benefits of n-3 polyunsaturated fatty acids exposure from fish consumption

Concluding Remarks

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ICMGP 2009
Guizhou, June 9, 2009

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

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ELSEVIER

Associations of maternal long-chain polyunsaturated fatty acids, methyl mercury, and infant development in the Seychelles Child Development Nutrition Study

J.J. Strain[a,*], Philip W. Davidson[b], Maxine P. Bonham[a], Emeir M. Duffy[a], Abbie Stokes-Riner[b], Sally W. Thurston[b], Julie M.W. Wallace[a], Paula J. Robson[a], Conrad F. Shamlaye[c], Lesley A. Georger[b], Jean Sloane-Reeves[b], Elsa Cernichiari[b], Richard L. Canfield[d], Christopher Cox[e], Li Shan Huang[b], Joanne Janciuras[b], Gary J. Myers[b], Thomas W. Clarkson[b]

- found significant associations between different measures of LCPUFA and child development
- possible attenuation of such effects by MeHg
- found potential adverse associations between MeHg and outcome that were uncovered only when LCPUFA were included in the regression analyses

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Current State of Knowledge

- Benefits of fish consumption are significant
- Significant negative effects associated with Hg exposure/burden were observed at different age

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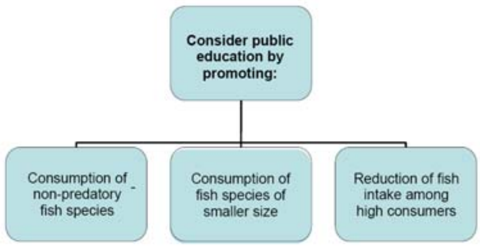
Hg burden in different populations

	Mean Hg conc in hair (ppm)
Korea	0.82
Japan	2.47,1.65
US (Korean)	0.6
US (Japanese)	1.2
China (Zhoushan)	1.25
Japan (pregnant women)	1.97
US (pregnant women top decile)	0.8

Public Health challenges

- Different countries/agencies setting different guideline levels
- Different public health messages given to populations showing similar level of exposure/burden...causing confusions?
- What actions do we need to take when high percentage of the average population exceeds the guideline level?

Options for Public Education (WHO 2008)

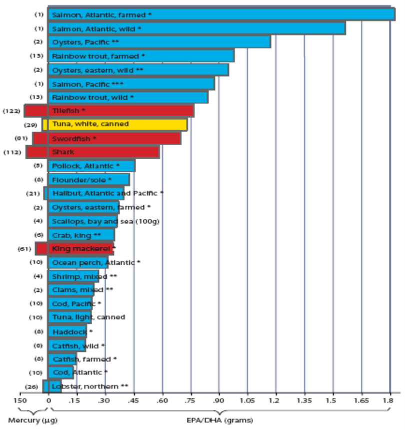


Fish Concentration Limits

Hg level in fish (ppm)	***Fish consumption/wk (kg)***
1	0.08
0.5	0.16
0.4	0.20
0.3	0.26
0.2	0.40
0.1	0.80

Based on assumption of 0.16 ug MeHg/Kg BW/day and 70Kg BW

2 Servings per week or about 0.4 kg/wk



NAS, 2006

Software to optimize the balance between the intake of macro/micronutrients and chemical contaminants

Schuhmacher M et al. See poster session

About 20% of the world's population derives at least one-fifth of its animal protein intake from fish (WHO, 2009)

It is important to communicate the risk to the public without scaring them to the point that they would stop eating fish altogether.

谢谢你

ポスターセッション

プロシーディングス

発表データ

（※発表データはオーラル発表者のみ）

Nutrition transition of the Amazon Basin: Impact of fish consumption on growth of exclusively breastfed infants during the first 5 years

José G. Dórea,[1] Rejane C. Marques,[2] José V. E. Bernardi, [1] Katiane G. Brandão,[2] Wanderley R. Bastos,[2] Olaf Malm.[3]

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Abstract

Changing fish-eating habits due to fast urbanization of Amazonians is a fact; we investigated whether maternal frequency of fish consumption may impact on children's weight and height during the first 5y. A longitudinal study (birth to 5 years) examined the impact of frequency of fish consumption and the influence of exclusive breastfeeding (> six months) on growth of a sample of 82 urban children from Porto Velho, Western Amazon. We used Hg concentration in hair as a marker of fish consumption. Detailed information concerning diet, anthropometry (and infant growth and development) was completed for 82 mother-infant pairs. Infants and children were measured and weighed at birth and at 6 (exclusive breastfeeding), 36 and 60 months. Only at birth and six months, Hair-Hg (HHg) concentrations were substantially elevated in both mothers and infants (but were not statistically significant). HHg (fish consumption) had no significant impact on children' weight and height at the specified ages. Compared to other sampling periods, after exclusive breastfeeding (6 m) analysis by Z-scores showed the highest proportion of children (14/82, 36/82, 52/82) respectively for length/height-for-age (H/A), weight-for-age (W/A), and weight-for-legth (W/H) Z-scores (<-1 SD). There was a wide variation in birth weight (range: 2.2 to 4.3 Kg); however, exclusive breastfeeding substantially lowered (by 50%) the range of body mass at 6 months (6.1 to 8.5 kg). Weaning (with extended breastfeeding) had a substantial impact in moving up the attained growth at 3y; the duration of breastfeeding was significant correlated with attained Z-scores for W/A ($r=0.2608$; $p=0.0179$) and W/H ($r=0.2269$; $p=0.0404$) but not for H/A. At 3y most children improved Z-scores (> -1 SD) for H/A (12/82), W/A (8/82) and W/H (8/82). At 5y, all but one child attained Z-scores > -1. Although hair-Hg is an indicator of fish-methylmercury exposure, in this study it was a more precise indicator of fish consumption. The results indicate that the main source of dietary protein consumed by the family was successfully substituted by other sources of protein, but extended breastfeeding had a significant impact on profiles of attained height and weight at 3y; thus indicating that extended breastfeeding can be an important nutritional modifying-factor of weaning.

Key words: Breastfeeding, growth, fish, catch-up.

1. Introduction

Fish is an abundant natural resource in the Amazon rain forest that is highly consumed by traditional communities. In this context, the high protein content of fish balances high starchy food consumed by these communities providing much needed sulphur amino-acids and bioavailable iodine, both crucial to counterbalance cassava goitrogens and low I-foods produced in I-depleted soils of tropical rain forests.

During the last 30y the city of Porto Velho, capital of the state of Rondonia (West Amazonia), has experienced significant demographic changes; as a result of gold prospecting and agricultural development it has changed its traditional Amazonian characteristics. With people coming from many other Brazilian regions, the present population has both traditional families that base their diets on fish and starchy foods and city dwellers with more cosmopolitan food habits. In this changing environment we investigated the growth of a sample of urban breastfed infants with special reference to family fish consumption.

The effects of maternal fish consumption on infant growth may start early during pregnancy. The importance of adequately supplying protein during pregnancy and lactation to ensure full reproductive success is well-recognized. In the present study we aimed to investigate whether maternal frequency of fish consumption may impact on children's weight and height during the first 5y including a 6m of exclusive breastfeeding.

2. Subjects and Methods

The study protocol was approved by the Ethics Committee of Studies for Humans of the Universidade Federal de Rondonia and details have been published (Marques et al, 2007a, 2007b). During routine visits to the Pre-natal Clinics of three hospitals in Porto Velho pregnant mothers between the ages of 15 and 45y were initially recruited; the mothers were selected among those in good health, reporting no illness or complaints at the time of the study and who were willing to breastfeed. Excluding factors were occupational exposure to toxic chemicals and hereditary neurological illnesses. Written consent (stating that participation was voluntary and confidentiality was assured) was signed by the participant mother, who could withdraw from the study at any time.

Recruitment of mothers began in 2000 and detailed information concerning diet, anthropometry (and infant growth and development) was completed for 82 mother-infant pairs. At birth and at ages of 6, 36 and 60 months anthropometric measurements of mothers and infants were taken; weight and height were measured by trained nurses and regularly monitored according to standard procedures. Length of newborn babies and 6 month-old infants were measured in recumbent position with a 0.1 cm stadiometer. At 36m and 60m the children were measured and weighed barefoot and dressed in underwear only; standing height was measured to the nearest 0.1 cm and weight is measured to the nearest 0.1 kg with an electronic scale.

Z scores for attained weight-for-age, length-for-age, BMI-for-age and weight-for-length were based on the WHO Child Growth Standards (2006). Therefore, the weight-for-height Z scores (WHZ) were calculated by using EPI-INFO (version 4.1; Centers for Disease Control and Prevention, Atlanta) and the World Health Organization recommended growth curves. At the specified age, during the anthropometric measurements we also collected samples of hair from mothers and respective children and determined Hg concentrations according to standard procedures of our laboratories.

3. Results and Discussion

Infant characteristics at birth as a function of frequency of maternal fish consumption were not significant different between groups. Only at birth and 6m, HHg concentrations were substantially increased in both mothers and infants but were not statistically significant. Attained Z-scores was not statistically significant different between groups. Also, no significant association was noticed between HHg and respective attained Z-scores.

At birth, most children showed adequate Z-scores (> -1) for length-for-age (90%), weight-for-age (14/82) and weight-for-length (26/82). However, attained growth at 6m showed remarkable differences: the infants grew much more in height than in weight: the proportion of infants with attained growth (Z-scores < -1) was 14/82, 36/82 and 52/82 respectively for length-for-age, weight-for-age, and weight-for-length. Most children showed Z-scores (> -1) for height-for-age (12/82), weight-for-age (8/82) and weight-for-height (8/82). However it should be noticed that only one child had Z-score > -2 for length-for-age during breastfeeding, but 5 showed stunting at 36m. Malnutrition (weight-for-age < -2) was seen in only two breastfed infants. All but one child attained Z-scores > -1 at 60m. Part of the nutritional outcome due to the quality of the weaning diets was due to extended lactation.

The duration of breastfeeding did seem to interact with the dietary patterns of weaning; there was significant correlation with attained Z-scores at 36m for weight-for-age (r=0.2608; p=0.0179) and weight-for-length (r=0.2269; p=0.0404) but not for length-for-ag. There was a wide spread in birth weight (range: 2.2 to 4.3 Kg); however, exclusive breastfeeding substantially reduced (by 50%) the range of body mass at 6m (6.1 to 8.5 kg).

Quality of the diet for pregnant and lactating women is a key issue in public health nutrition, especially in poor communities with economic constrains. The mothers of Porto Velho, with respect to levels of dietary fish consumption, showed no significant impact on the attained growth of their young children; this indicates adaptation to changes from traditional fish-based diet to other sources of protein. By examining the longitudinal growth of their children it was revealed that mothers' milk, irrespective of level of fish consumption, could compensate for restrictions in birth weight; furthermore, the length of lactation (beyond 6m) was an important nutritional supplement measurable at 3y.

The results indicate that regardless of protein source, the habitual plane of nutrition was sufficient to sustain satisfactory Z-Scores for weight and height at 5y. HHg – signature of fish consumption - was not associated with infant growth but extended breastfeeding had a significant impact on profiles of attained height and weight at 3y; thus indicating that breastfeeding can be an important modifying factor of weaning.

発表データ

Nutrition transition of the Amazon Basin: Impact of fish consumption on growth of exclusively breastfed infants during the first 5 years

José G. Dórea ; Rejane C. Marques; Olaf Malm; José V. E. Bernardi; Katiane G. Brandão; Wanderley R. Bastos

BACKGROUND

Changes in fish-eating habits due to rapid urbanization in Western Amazon was used as model to investigate whether maternal fish-intake rate impacts on children's weight and height during the first 5 years.

- **OBJECTIVE**
- The study examined the growth of 82 breastfed children, and maternal fish consumption (hair mercury concentrations, HHg) during pregnancy and lactation.

- **RESULTS**
- Fish consumption rate (HHg) had no significant impact on children's growth at the specified ages ($p=0.35$).

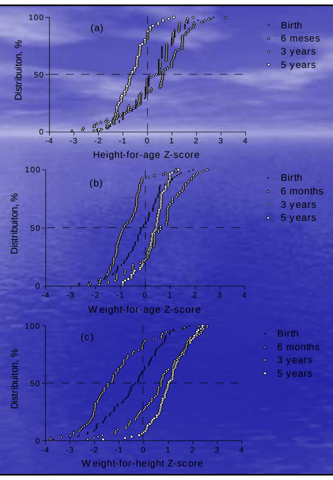
- After 6 months of exclusive breastfeeding, children had the highest proportion of Z-scores <1 SD; however, weaning (with extended breastfeeding) had a substantial impact in moving up the attained growth at 3 years.

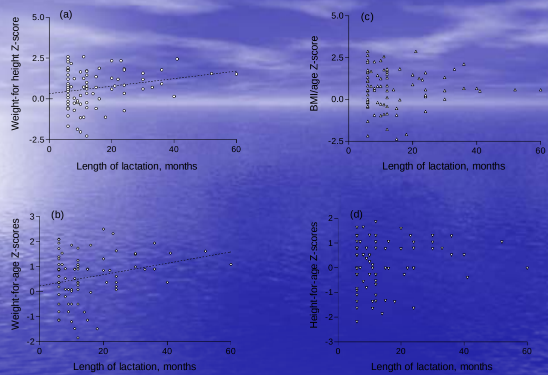
The duration of breastfeeding was significantly correlated with attained Z-scores for weight-for-age ($r=0.26$; $p=0.02$) and weight-for-height ($r=0.22$; $p=0.04$) but not for height-for-age. At 3 years most children had improved Z-scores (>1 SD) for height-for-age (70/82), weight-for-age (74/82) and weight-for-height (74/82). At 5 years, all but one child attained Z-scores >1.

Table I. Maternal and infant HHg concentrations ($\mu g.g^{-1}$) as a frequency of fish consumption of mothers.

Fish/w		Birth		6 months		3 years		5 years	
	n	*Mot*	*Inf*	*Mot*	*Inf*	*Mot*	*Inf*	*Mot*	*Inf*
0–1	49	6.0±5.5	2.0±2.3	2.6±2.6	3.1±4.5	2.4±2.6	2.5±4.2	2.2±2.4	2.5±3.8
≥2	33	9.4±11.8	3.1±3.8	2.8±3.1	5.0±6.7	3.4±4.0	2.6±3.0	3.1±3.8	2.8±3.1
p		0.09	0.08	0.09	0.13	0.21	0.91	0.21	0.66

mean±SD





- **CONCLUSION**
- The apparently good nutritional status of subjects is more likely due to a well balanced diet composition than to only one dietary protein source – fish.

Total and methylmercury in maternal and cord blood of pregnant women in Korea

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Abstract
The exposure level of mercury in the pregnant woman influence on the health of fetus directly. This study was designed to examine the mercury(Hg) level of pregnant women and the main causes of exposure in Korea. Questionnaire information about dietary habit, dental amalgam use, recent vaccination, etc. were asked, and two types of blood; venous and cord blood were sampled from 141 volunteer pregnant women in Seoul and Pusan area, Korea. Total mercury (THg) was analyzed from total samples and methyl mercury (MeHg) was done from 36 samples selected randomly. THg were 1.02～11.53ppb, 1.48～15.97ppb in venous and cord blood respectively. The THg in cord-blood was about 150% than that in venous blood in concentration. MeHg levels of 36 participants were 2.60±1.11ppb in venous blood and 4.70±1.97ppb in cord-blood. It was identified that MeHg were 85% and 91% level of the THg in venous and cord blood of Korean pregnant women. The close relationship was not found between dental amalgam treatments and Hg concentration within recent 6 months. Some participants who had vaccinations showed high concentration of Hg in their blood and cord blood, but it didn't show the statistical significance. On the other hand, fish intake was an important factor in Hg level of the pregnant women in Korea. Hg concentration showed increasing tendency according to the increase of fish intake. The further studies are suggested that Hg levels in fishes could be investigated. In the mean while, it is recommended to reduce Hg intake in pregnant woman.

Keywords: Methyl Mercury; Total Mercury; fish intake; cord blood; pregnant woman

1. Introduction

Mercury (Hg) is one of the heavy metals which have high toxicity and is being regarded as a pollutant requiring special management. Even only a small amount is released in the environment, mercury causes bioaccumulation in the ecosystem. According to UNEP/Global mercury Assessment report (2002), Asian countries occupy 45% of world mercury emission.

Hg accumulates in the body not only through digestive organ but also skin or respiration. Hg influences on all the human organs including the central nervous system and the circulatory organs. Hg accumulation is especially hazardous to children and babies because it has fatal effects on their brain. Moreover, Hg is the most sensitive to fetus because of its serious effect on the development of nerve system. The exposure level of Hg in the pregnant woman influence on the health of fetus directly. In these reasons, to know how the measure of Hg in the woman is very important.

On the other hand, Korean government got the value of blood Hg of general population from The 1st National Survey for Heavy Metals, which was 4.25 ppb in 2005. The result was regarded that mercury exposure by Korean people is relatively higher than that of other countries. This study was accomplished in order to know the Hg level of pregnant women and the main causes of Hg exposure in Korea.

2. Materials and Methods:

One hundred forty-one healthy volunteer pregnant women without any particular vocational exposure to mercury were recruited in Seoul and Busan, Korea. Questionnaire information about dietary habit of fish intake, dental amalgam use and recent vaccination were asked, and two types of blood; venous and cord blood were sampled. Venous blood was sampled when pregnant women visited hospital for delivery and Cord blood samples were collected immediately after birth.

Samples were stored at -80°C until analysis. Total mercury (THg) was analyzed from total samples using the gold amalgam collection method and methyl mercury (MeHg) was done from 36 samples selected randomly using the dithizone extraction method.

3. Results and Discussion

The average THg was 3.99±1.55ppb with the range of 1.02 ～11.53 ppb in venous blood, and 5.87±2.25ppb with the range of 1.48～15.,97 ppb in cord blood, respectively. The THg in cord-blood was about 147% than that in venous blood in concentration. Table 1 shows Hg level in maternal and cord blood.

Table 1. Mercury Exposure Level

(unit : ppb)

	Maternal Blood(A)	Cord Blood(B)	Ratio of B/A
Seoul (N=84)	4.26±1.51 (1.44～11.53)	5.84±2.17 (1.66～12.97)	1.37
Busan (N=57)	3.59±1.54 (1.02～9.31)	5.91±2.38 (1.48～15.97)	1.65
Total (N=141)	3.99±1.55 (1.02～11.53)	5.87±2.25 (1.48～15.97)	1.47

Euyhyuk Kim et al. (2006) reported mercury level in pregnant women who visited obstetrics in their hospital in Seoul to be 4.8ug/L in maternal blood, 5.4 ug/L in cord blood.

The close relationship was not found between dental amalgam treatments and Hg concentration within recent 6 months. Some participants who had vaccinations showed high concentration of Hg in their blood and cord blood, but it didn't show any significant difference statistically ($p>0.05$). On the other hand, fish intake was an important factor in Hg level of the pregnant women in Korea. Hg concentration showed increasing tendency according to the increase of fish intake. Preference level of fish intake also showed difference in the concentration of THg. High preference group showed higher level than low preference group on average value. According to H.J. Park et al. (2008), hair Hg level showed difference by fish preference level in Chinese and Korean school children. The amount of fish intake also showed difference in hair Hg level. B.M. Kim et al (2008) presented that the frequency of fish intake brought a significant difference in Hg level in maternal and cord blood in Seoul area.

MeHg levels of 36 participants were 2.60±1.11ppb in venous blood and 4.70±1.97ppb in cord-blood. It was identified that MeHg were 85% and 91% level of the THg in venous and cord blood of Korean pregnant women respectively. Table 2 shows compared level of T-Hg abd Me-Hg in maternal blood and cord blood.

Table 2. Comparison of T-Hg and Me-Hg.

(unit : ppb)

Division	T-Hg	Me-Hg	Ratio of Me-Hg/T-Hg(%)
Maternal blood(n)	3.06±1.17 (36)	2.60±1.11 (36)	84.5
Cord blood(n)	5.20±2.36 (36)	4.70±1.97 (36)	90.8

It was assumed that 2.8% in maternal blood samples and 22% in cord blood samples from participants exceeded the guideline value of US EPA(5.8ppb). MeHg is one of the substances most risky to fetal brain development, and most of the exposure to MeHg is through maternal fish consumption (IPCS, WHO 1990).

4. Conclusions

THg and MeHg were analyzed in vein and cord blood sampled from 141 volunteer pregnant women in Seoul and Pusan, Korea. THg in vein and cord blood were 3.99±1.55ppb, 5.87±2.25ppb, and MeHg were 2.60±1.11ppb, 4.70±1.97ppb. It was identified that MeHg were 85% and 91% level of the THg in vein and cord blood of Korean pregnant women respectively. The frequency of fish intake was an important factor in Hg level of the pregnant women. The further studies are suggested that Hg levels in fishes could be investigated. In the mean while, it is recommended to reduce Hg intake in pregnant woman.

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Total and Methyl Mercury in Maternal and Cord Blood of Pregnant Women in Korea

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9th ICMGP, Guiyang, China

National Institute of Environmental Research

ICMGP Guiyang, China : June 7-12, 2009

Contents

1. Introduction

Hg
Mercury

• Background

- Asia occupies 45% of world mercury emission(UNEP/GMA, 2002)
- Blood Hg of general population in Korea was relatively high. (4.25 ppb in The 1st National Survey for Heavy Metals, 2005)
- Concerns of Hg exposures and health effects are increased

• Purpose

- Hg influences on all the human organs including the central nervous system and the circulatory organs
- Hg is very sensitive to fetus by the development of nerve system.
- To know how the measure of Hg in the woman is very important.
- This study was accomplished in order to know the Hg level of pregnant women and the main causes of Hg exposure in Korea.

2. Materials and Method

• Sampling

- 141 volunteer pregnant women in Seoul and Pusan area
- two types of blood; venous and cord blood were sampled

• Questionnaire

- dietary habit, dental amalgam use, recent vaccination, etc.

2. Materials and Method(continued)

• Analysis

T-Hg was analyzed with auto mercury analyzer using gold amalgam collection method.

Me-Hg was analyzed by the dithizone extraction method using GC-ECD.

Biological Sample(<0.5g)
1N KOH-1EtOH 10ml – heat 1hr
Digested sample 1N HCl 10ml,5ml Hexane wash
Aqueous layer
20%EDTA 2ml , extracted with 0.01% Dz-Toluene, 5ml
Organic layer
Aqueous layer
Oragnic layer
Washed Twice with 1N NaoH, 3ml Acidified with 1N HCl, 2hrs
GC- ECD

3. Results

Table 1. Mercury Exposure Level

		Maternal Blood	Cord blood	Cord/Maternal
Total Mercury (ppb)	Seoul (N=84)	4.26±1.51 (1.44 - 11.53)	5.84±2.17 (1.66 - 12.97)	1.37
	Pusan (N=57)	3.59±1.54 (1.02 - 9.31)	5.91±2.38 (1.48 - 15.97)	1.65
	Total (N=141)	3.99±1.55 (1.02 - 11.53)	5.87±2.25 (1.48 - 15.97)	1.47

3. Results(continued)

Table 2. Preference of Fish Intake

unit : ppb

Preference Degree	Maternal Blood		Cord Blood	
	n	Concentration	n	Concentration
High	79	4.01±1.40	79	5.94±1.89
Low	36	3.95±1.74	36	5.44±2.29

Table 3. Amount of Fish Intake

unit : ppb

Fish Intake/wk	Maternal Blood		Cord Blood	
Number	n	Concentration	n	Concentration
<1/2	66	3.93±1.60	66	5.67±2.26
1/2 – 1	62	3.97±1.42	62	5.94±1.97
>1	6	5.00±2.26	6	7.90±4.22

3. Results(continued)

Table 4. Blood Hg Level by other factors

		Yes (n)	No (n)	Total (n)	*p*-value
Amalgam use within 6 months	maternal (ppb)	4.11±1.61 (7)	4.18±1.61 (102)	4.17±1.61 (109)	0.922
	cord (ppb)	4.84±2.34 (7)	6.03±2.34 (102)	5.96±2.35 (109)	0.196
vaccination within 1 year	maternal (ppb)	4.03±1.59 (126)	3.45±1.01 (9)	3.99±1.56 (135)	0.285
	cord (ppb)	5.96±2.32 (126)	4.72±1.08 (9)	5.88±2.27 (135)	0.113

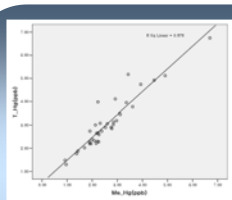
3. Results(continued)

Table 5. Comparison of T-Hg and Me-Hg

Contents	T-Hg(ppb)	Me-Hg (ppb)	Me-Hg/T-Hg ratio(%)
Maternal Blood (N=36)	3.06±1.17	2.60±1.11	84.5
Cord blood (N=36)	5.20±2.36	4.70±1.97	90.8

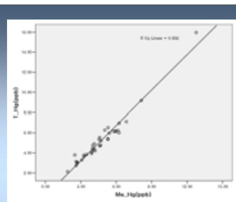
3. Results(continued)

• Correlation between T-Hg & Me-Hg



Maternal Blood
(Pearson correlation R=0.937, p<0.001, *n = 36).

Fig. 4. Correlation between T-Hg & Me-Hg in Maternal Blood



Cord Blood
(Pearson correlation R=0.978, p<0.001, *n = 36).

Fig. 5. Correlation between T-Hg & Me-Hg in Cord blood

4. Conclusions

T-Hg and Me-Hg were analyzed in venous and cord blood sampled from 141 volunteer pregnant women in Seoul and Pusan, Korea.

T-Hg was 3.99±1.55ppb in venous & 5.87±2.25ppb in cord Blood. It was assumed that Me-Hg was about 85% and 91% level to T-Hg in venous and cord blood of Korean pregnant women, respectively.

Fish intake was identified to be an important factor in Hg level of the pregnant women.

The further studies were suggested that Hg level in fish could be investigated. In the mean while, it was recommended to reduce mercury intake in pregnant woman.

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MERCURY IN HAIR AS A DIAGNOSTIC INDICATOR OF EXPOSURE TO THE METAL IN A COASTAL POPULATION IN VENEZUELA.

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ABSTRACT
Total and methylmercury in hair (THg-H and MeHg-H) were determined in 160 adults to characterize them in terms of Hg-exposure and potential risk. The study group constituted of 60 individuals living in the Central-North coast of Venezuela. The control group included 100 individuals selected from Carabobo State with no-known exposure to Hg. A questionnaire collected demographic, health information, work activities and fishing consumption habits. Hair samples were analyzed for THg. Samples with THg-H > 5 ug/g were also analyzed for MeHg. The mean THg-H was 1.88 ± 1.50 and 0.99 ± 0.87 ug/g for the study and control groups, respectively. The study group was statistically higher than control, however, no statistical differences on THg-H between each of the 4 categories of the study group and control group were found. Mean MeHg-H value was 3.67 ± 1.25 ug/g. No significant relation was noted between Hg-H levels and clinical symptoms. R analyses and t-tests showed the main predictors of THg-H levels in the study group were fish consumption and its frequency. The results of this study indicate that Hg exposure did not exceed safe levels. However, a more in-depth exposure assessment should be conducted to characterize more accurately this exposure, mainly in terms of water and fish sampling for Hg content.

Key words: Mercury; exposure; mercury in hair

INTRODUCTION
This work was done at the Puerto Cabello-Moron coastal area of Venezuela. Part of the area was known to be contaminated with mercury (Hg) because of the installation of a chlor-alkali plant in a petrochemical complex that was close to one of the tributaries' rivers that empties into the Caribbean Sea **(1,2).** Mercury spills from these plants produced concern in the 70 km coastal zone studied. During the years following the spill, several potentially polluting industries were built in the area where some of the villagers consumed fish as their main source of food intake. The authors have updated part of the above mentioned surveillance and have investigated the current potential Hg-contamination in a selected population of villagers in the region of Puerto Cabello-Moron coastal area of Venezuela.

METHOD
Study group: 60 individuals living at the Central-North coast of Venezuela (Falcon-Carabobo States) selected according to the following criteria:

- Retired individuals that worked in the petrochemical industry at the time of the contamination (n=20);
- Current petrochemical workers (n=13);
- People living in a fishing village (with high fish intake, locally caught) located at 10 km from the petrochemical industry (n=14).
- People living in Puerto Cabello, a big Carabobo State port, located at 20 km from the petrochemical industry and whose fish intake is also high (n=13).

Control group: 100 individuals (50 male; 50 female) from Valencia, Carabobo State with no-known Hg-exposure. A questionnaire including socio-demographic information, health history, Hg-related signs/symptoms, work activities, life styles and fish consumption was given by interview to both groups. Hg exposure was evaluated by measuring its content in hair. Samples were analyzed at the Laboratory of the Sciences Institute for Minamata Disease. THg-H was determined in **Study and Control** groups by a flameless AA spectrometer. Samples with THg-H > 5 ug/g were also analyzed for MeHg. Written consent was obtained from the volunteers.
Descriptive statistics and Student's t test were used for the analyses. R package was used for the one-way analysis of variance **(3).** The proposed model estimated the relationship between the dependent variable THg-H and the independent variables sex, group classification, smoking and drinking habits, fish intake and frequency of fish intake.

RESULTS AND DISCUSSION

The sea species most frequently reported were: "Lisa" (Mugil sp), followed by "Pargo" (Lutjanus sp), Carite (Scomberomorus sp) and Tuna (Thunnus sp). Twenty five species were sea fish and four were river fish.

The **Study** group had statistically higher THg-H values ($p<0.01$) than control individuals. Levels of THg-H in the **Fishing village** were higher than the ones in other groups although not statistically different. This is probably due to the higher fish consumption. THg-H concentrations decreased in the following order: Fishing village > Current workers > Retired workers > Puerto Cabello, which is considered consistent with what was expected.

Mean levels of THg-H were below the safety limit reported by WHO (10 ug/g) and values of MeHg-H were not significant different from the permissible limit (2ug/g). Levels were lower than the associated with adults neurological damage (50 ug/g hair) and among children exposed *in uterus* (10 ug/g hair) **(4,5).** However, the statistically higher THg-H values in the study group may indicate that could exist a potential for Hg contamination in the area.

The only variables that could influence THg-H values in the study group were "fish intake" and "frequency of fish intake", as the probability of rejection of the F test is 0.035 and 0.034 respectively, which implies that they are significant at 4%. Other factors studied did not contribute significantly to THg-H levels.

As expected, there was an increase in THg-H concentrations in the **Study** group individuals whose frequency of fish intake was "daily". The fact that mean THg-H value of the Fishing village residents was the highest in the study group (2.5 ± 1.56 ug/g) and 57% of this population reported a *daily* frequency of fish intake (mean THg-H 3.55 ± 0.97 ug/g), indicates that diet factors contributed importantly to Hg-H levels. These findings suggest that the fish from that area may be contaminated with Hg although with permissible levels.

From the 23 investigated Hg-related signs/symptoms, in the study group, 46.7% individuals reported some type of sign and/or symptom and the most reported in that group (all frequencies) were: sleepiness (21.7%), hearing disturbance (16.7%), anxiety and sadness (11.7%) and tremor (10%). No significant relation was noted between THg-H levels and symptoms in the current study. The symptoms most frequently reported as "very frequently" was headache (13.3%) and joints pain (10%). Since all Hg-H concentrations were below 10 ug/g (limit where clinical signs are not apparent) (6), signs/symptoms reported could not be considered specific to Hg so we cannot derive definitive conclusions from these results. However, a more in-depth exposure assessment should be conducted to characterize more accurately this exposure mainly in terms of water and fish sampling for Hg content.

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発表データ

MERCURY IN HAIR AS A DIAGNOSTIC INDICATOR OF EXPOSURE TO THE METAL IN A COASTAL POPULATION IN VENEZUELA.

Authors:
Rojas Maritza, Nakamura Kunihiko, Seijas D, Squillante G, Pieters M, Infante S.

Introduction

- Place of study: Puerto Cabello-Morón. Venezuela
- Part of area known to be contaminated with Hg because of a chlor-alkali plant in a petrochemical complex, close to one of the tributaries' rivers
- Years after spill several polluting industries were built in the area where most of villagers consumed fish as their main source of food intake
- Some of the villages studied: fish is the primary and frequently the only source of animal protein
- Ingestion of Hg contaminated fish: MeHg is easily bio-accumulated and bio-magnified and becomes concentrated in fish

OBJECTIVES AND METHODOLOGY

- To characterize selected population in terms of Hg-exposure and potential risk Analytical, case-control study.
- Study group: 60 individuals living at Central-North coast of Venezuela (Falcon-Carabobo States)
- Inclusion criteria:
  - Retired individuals that worked in the petrochemical industry at the time of contamination (n=20);
  - Current petrochemical workers (n=13);
  - People living in a fishing village (with high fish intake) at 10 km from the petrochemical industry (n=14).
  - People living in Puerto Cabello, a big Carabobo State port, located at 20 km from the petrochemical industry and whose fish intake is also high (n=13).

Methodology

- Control group: 100 individuals (50 male; 50 female) with no-known Hg-exposure.
- Questionnaire: socio-demographic data, health history, Hg-related signs/symptoms (last 2 years), work activities (potential Hg exposure) and life styles.
- Consumption of fish (yes/no), type of fish and average number of times/week they ate fish (past 6 months).
- Frequency of fish intake (Daily; 2-5x/week; 1-3x/week; Do not eat fish).
- THg-H: determined by flameless AA spectrometer with a mercury analysis vaporizer (Rigaku Mercury SP-1; Nippon Instruments Co. Ltd, Tokyo).
- Samples with THg-H > 5 ug/g were also analyzed for MeHg

Statistics

- Descriptive statistical analyses were used to illustrate socio-demographic variables and concentrations of Hg-H and to characterize the fish diet.
- Mean comparisons: carried out using the Student's t test.
- R package: used for the one-way analysis of variance

Results

- Twenty nine fish species were reported. From these, the sea species most frequently reported were: "Lisa" (Mugil sp), followed by "Pargo" (Lutjanus sp), Carite (Scomberomorus sp) and Tuna (Thunnus sp).
- Apart from tuna, we did not find the fish species more susceptible of Hg uptake as reported by other researchers (7, 22).
- 25 species were sea fish and 4 were river fish.

TABLE I. DISTRIBUTION OF THE *STUDY GROUP* ACCORDING TO SEX, AGE AND Hg-H VALUES (ug/g).

AGE (Years)	SEX	THg	THg-H n	THg-H % (1)	THg-H X ± SD (R)	MeHg-H X ± SD (R)
47.47 ± 14.66 (R= 21-74)	Male	< 5	33	58.92	1.53 ± 1.05 (0.21-4.38)	-
		≥ 5	3	75	5.78 ± 1.05 (5.16-7.00)	3.85 ± 1.47 (2.17-4.90)
		Total male	36	60	1.88 ±1.57 (0.21-7.00)	-
	Female	< 5	23	41.08	1.72 ±1.21 (0.31-4.70)	-
		≥ 5	1	25	5.61	3.14
		Total female	24	40	1.88 ±1.42 (0.31-5.61)	-
	Total Study G.	< 5	56	100	1.61 ±1.11 (0.21-4.70)	-
		≥ 5	4	100	5.74 ±0.86 (5.16-7.00)	3.67 ± 1.25 (2.17-4.90)
		Total	60	100	1.88 ± 1.50(*) (0.21-7.00)	-

R: Range
(1): % based on each total according to THg values < 5 ug/g (n=56) and ≥ 5 ug/g (n=4);
(*): Significant difference with respect to Control group (t-Student for independent samples)

TABLE II. DISTRIBUTION OF THE *CONTROL GROUP* ACCORDING TO SEX, AGE AND Hg-H VALUES (ug/g).

AGE (Years)	SEX	THg -H	THg-H (2) n	% (1)	X ± SD (R)
36.86 ± 12.35 (R= 18-74)	Male	< 5	50	50	1.08 ±0.84 (0.13-4.37)
	Female	< 5	50	50	0.90 ±0.89 (0.09-4.31)
	Total Control Group	< 5	100	100	0.99±0.87 (3) (0.09-4.37)

R: Range
(1): % based on the total with THg-H <5 ug/g (n=100).
(2): All < 5 ug/g
(3): Significant difference with respect to Control group (t-Student for independent samples)

TABLE III. "STUDY" GROUP ACCORDING TO CLASSIFICATION AND MEAN VALUES OF Hg-H

Classification	THg-H (ug/g)	THg-H (ug/g) n	% (1)	X± SD (*)	MeHg-H (ug/g) X ± SD
Retired workers	< 5	18	32.1	1.07±0.75	-
	≥ 5	2	50	6.09±1.27	3.33±1.64
	Total	20	33.3	1.57±1.72	-
Current workers	< 5	13	23.2	2.04±1.07	-
	≥ 5	0	-	-	-
Fishing Village	< 5	13	23.2	2.29±1.42	-
	≥ 5	1	25	5.16	4.90
	Total	14	23.3	2.50±1.56	-
Puerto Cabello	< 5	12	21.4	1.20±0.63	-
	≥ 5	1	25	5.61	3.14
	Total	13	21.6	1.54±1.36	-
TOTAL	< 5	56	100	1.61±1.11	-
	≥ 5	4	100	5.74±0.86	3.67±1.25
	Total	60	100	1.88±1.50	-

(1): % based on each frequency according to THg values: < 5 ug/g (n=56) and ≥ 5 ug/g (n=4);
(*): No statistical differences between studied groups (one-way ANOVA)

RESULTS & DISCUSSION

- Both mean values were lower than the ones reported in studies from other countries such as Brazil (21, 22). However, the statistically higher THg-H values in the *Study* group may indicate a potential for Hg contamination in the area.
- Levels of THg-H in the *Fishing village* group were higher than the ones other groups although not statistically different, probably d to the higher fish consumption.

RESULTS & DISCUSSION

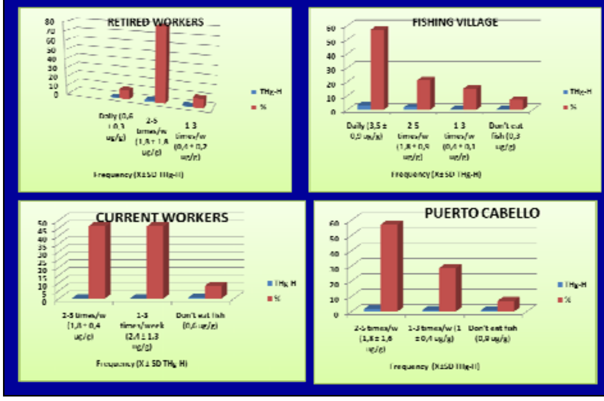
- As expected, *Fig. 2* shows an increase in THg-H concentrations in the study group individuals whose frequency of fish intake was "daily".
- The fact that mean THg-H value of the *Fishing villagers* was the highest in the study group (2.5 ± 1.56 ug/g) and 57% of this population reported a *daily* frequency of fish intake (mean THg-H 3.55 ± 0.97 ug/g), indicates that diet factors contributed importantly to the Hg-H levels.

RESULTS & DISCUSSION

- THg-H concentrations : Fishing village > Current workers > Retired workers > Puerto Cabello, which is considered consistent with what was expected.
- According to the analysis of variance used, the only variables that could influence the THg-H values in the *Study group* are "fish intake" and "frequency of fish intake".
- Other factors studied did not contribute significantly to

  THg-H levels.

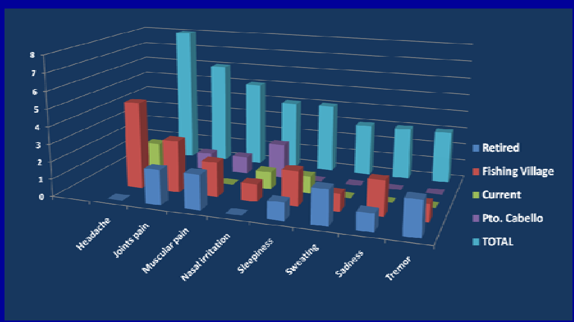
Fig. 4. FREQUENCY OF FISH INTAKE IN AND MEAN VALUES OF THg-H (ug/g) IN THE *STUDY GROUP*



RESULTS & DISCUSSION

- Mean levels of THg-H were below the safety limit reported by WHO (10 ug/g)
- Values of MeHg-H were not significant different from the permissible limit (2 ug/g)
- None of the women studied had THg-H > 10 ug/g reported as the upper limit guideline for pregnant women
- Participants' levels were lower than levels associated with risk of neurological damage to adults (50 ug/g hair) and among children exposed *in uterus* (10 ug/g hair)

Fig. 3. MAIN SYMPTOMS OF THE *STUDY GROUP* ACCORDING TO CLASSIFICATION AND WHOSE PRESENCE WAS "VERY FREQUENTLY", IN THE LAST 2 YEARS.



CONCLUSIONS

- Since all Hg-H concentrations were below 10 ug/g (considered as the limit below which clinical signs are not apparent) (24) , signs and or symptoms reported could not be considered specific to mercury intoxication so we can not derive definitive conclusions from these results.
- Findings suggest that fish from that area may be contaminated with Hg although with permissible levels.
- A more in-depth exposure assessment should be

Potential contamination of mercury from artisanal gold mining in the Talawaan watershed area, north Sulawesi, Indonesia

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Abstract

Mercury (Hg) discharge through the artisanal gold mining activities is one of the environmental concerns due to its emission that may follows natural methylation of mercury to result environmental contamination with an impact in human health. To assess potential impact of Hg emitted from such activities, sampling was carried out in a watershed area of Talawaan, north Sulawesi, Indonesia, where that type of mining are widely occurred. Sediment and biota were collected in riverine system, while human hairs were collected from the residents living in the remote area. Total mercury (THg) and methyl mercury (MeHg) were measured in each of the samples. The results showed that THg and MeHg were found in all samples. In sediments, the THg concentration mostly decreased with distance from the mining area. Ratio between THg-MeHg in sediment was 0.0035. Accordingly, since there is no anthropogenic source of MeHg in the area, methylation process of Hg was occurred along the riverine system. Methyl mercury was found in the human hair samples in various levels higher than the control value. Since the residents consumed fish from the river daily, mercury impact may potentially occur.

Keywords: methyl mercury, artisanal gold mining, north Sulawesi, Indonesia

1. Introduction

Artisanal gold mining activity in small-scale is mostly conducted by communities with the primitive techniques and equipments to recover gold. It spreads widely in developing countries (Ogola et al., 2002; de Lacerda, 2003), including Indonesia, such as in north Sulawesi (James, 1994; Kambey et al., 2001; Limbong et al., 2003). However, in contradiction, as it practically uses an amalgam technique using Hg to recover gold, it is one of the major environmental concerns of Hg sources (de Lacerda and Salomons, 1998; Kambey et al., 2001; Ogola et al., 2002; de Lacerda, 2003; Limbong et al., 2003). In north Sulawesi, approximately 200 tons of Hg is used annually in regard to this purpose (Kambey et al., 2001). Forty to 50% of the Hg used in amalgamation is estimated to be lost into rivers during the process as metallic Hg, and other (5 to 10%) Hg is lost into environment during the recovery of gold from Hg amalgam. Further estimation is approximately 1.32 kg loss of Hg for 1 kg gold production (Pfeiffer and Lacerda, 1988 cf de Lacerda and Salomons, 1998).

The objective of the present study is to assess potential contamination of Hg emitted from an artisanal gold mining area to the water-receiving area of Talawaan watershed by analyzing present concentrations and spatial distribution of total Hg (THg) and methyl Hg (MeHg) in sediments and biota, including in human scalp hairs, then discussing potential impacts on human health.

2. Subjects and Methods

Talawaan watershed covers an area of 34,000 ha. In 2004, artisanal gold mining activities cover an area of ± 822 ha at upper land are of the watershed in 8 villages (Wasian, Tatelu, Tatelu Rondor, Tatelu Warukapas, Talawaan, Kolongan, Tetey, and Mapanget) of north Sulawesi, in which about 2500 to 3000 miners involved (Lingkubi, 2004). The main river of Talawaan (TR), and the other two rivers [Kima (KR) and Bailang (BR)], are flowing through the watershed from the upper land area (artisanal gold mining area) to the beach. The rivers are used by the communities for daily activities (bathing, washing, and fishery).

Sampling was carried out along the three rivers (TR, KR, and BR). Stations were set at each of the rivers based on the distance from the mining area. Sediment and biota (snails, crabs, and fish) were collected at each station, while human hairs were collected from the residents living in an area remote but closely related to the riverine system of TR. Total mercury (THg) and methyl mercury (MeHg) were measured in each of the samples. While THg was

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measured using mercury analyzer, the MeHg was measured by a gas chromatograph with ECD detector after extracted by dithizone-sodium sulfide extraction method.

3. Results and Discussion

THg was detected in all samples that varied within sampling sites and sample types. The concentrations in the TR sediment varied following the sites from 0.078 to 1.137 ppm. The highest concentration was at the mining area and the lowest was at the river mouth. The mercury concentration decreased with distance from the mining area. The same pattern was also observed in the KR where the highest concentration (0.099 ppm) was found at the sites close to the mining area and the lowest one (0.022 ppm) was at the river mouth. In BR, the situation was somewhat different that the highest THg concentration (0.176 ppm) was found in the several hundred meters inside area of the river mouth with a thick precipitation of sediment and the lowest (0.009 ppm) was at just the river mouth.

The variation of the THg concentration in sediment showed in the sampling area was due mainly to an introduction of Hg from other source which mainly from anthropogenic one, as introduction of anthropogenic source of Hg may elevate its natural concentration (Yasuda, 2000). Hg discharged from amalgamation in the artisanal gold mining area is in an elemental form through the canals and rivers.

THg was also found in the biota samples in various levels based on the species. Source of the Hg is mostly from sediment where it plays a key role in controlling the metal concentrations in biota (Blanchette., 2001).

MeHg was found in all sediment samples in the ratio of THg-MeHg as 0.0035. It was also found in all samples of the biota. Accordingly, since there is no anthropogenic source of MeHg in the area, methylation process of Hg was occurred in sediment along the riverine system. Moreover, through food webs where bioaccumulation occurred, the concentration of the methylated Hg is increased and magnified (Lasut & Yasuda, 2008).

MeHg was also found in the human hair samples in various levels higher than the control value. Hg methylation generally increases its toxicity as a result of its enhanced penetration through lipid membranes (Bustamante et al., 2006) of organisms and human. Since the residents consumed fish from the river daily, mercury impact may potentially occur.

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Potential Contamination of Mercury from Artisanal Gold Mining in the Talawaan Watershed Area, North Sulawesi, Indonesia

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ICMGP 2009, China — Lasut & Yasuda — 1

Objective of the Study

General:

To assess potential contamination of Hg emitted from an artisanal gold mining area

Specific:

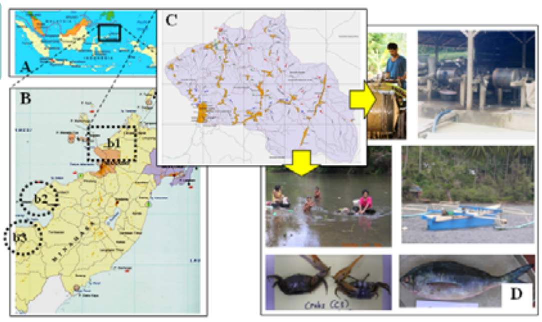
- **Analyzing present concentrations of total Hg (THg) and methyl Hg (MeHg)**
- **Analyzing spatial distribution**
- **Analyzing the potential contamination**

ICMGP 2009, China — Lasut & Yasuda — 2

STUDY AREA

(C): Talawaan Watershed Area

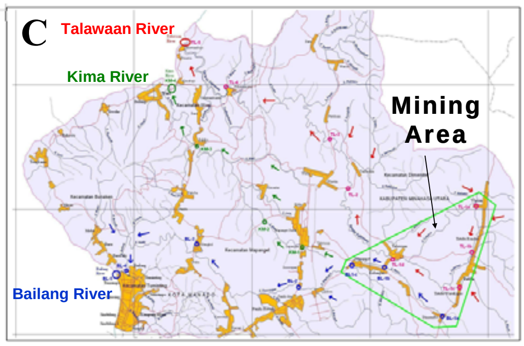
(D): Gold Mining Activities, Human Activities, Natural Resources



ICMGP 2009, China — Lasut & Yasuda — 3

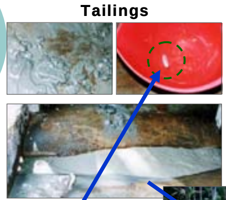
STUDY AREA

Talawaan Watershed Area



ICMGP 2009, China — Lasut & Yasuda — 4

Hg Discharge – Environmental Concerns



- The mercury is liberated to water and public facilities through rivers and canals
- The amount of mercury released is still immeasurable

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Hg Discharge – Environmental Concerns

For 1 unit of trommel/day (estimation):

- Hg consumption= 1 - 2 kg
- Hg reused= 0.8 - 1.8 kg
- Hg loss in process= 200 gr
- Hg releases to atmosphere (through burning amalgam)= 112 gr
- Hg release to drainage= **88 gr**

[If 500 unit for 1 year (200 days)]= 8.8 ton

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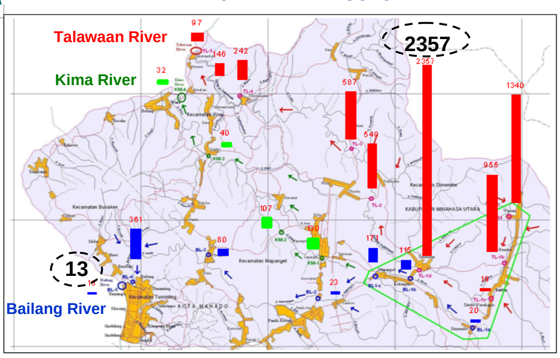
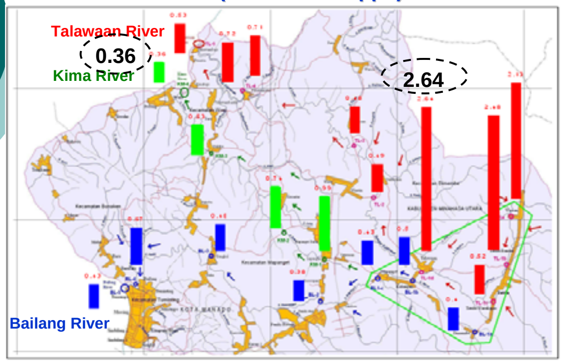
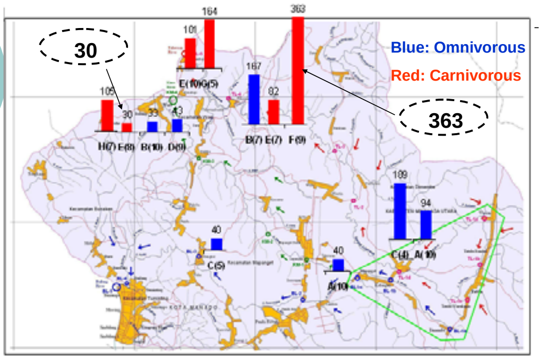
RESULT 1: Distribution of THg (ppb) in the Sediments
(Control: 5.8 ppb)



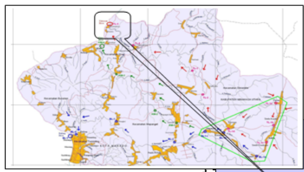
RESULT 2: Distribution of MeHg (ppb) in the Sediments
(Control: 0.22 ppb)



RESULT 3: MeHg (ppb) in Fish (meat)
Control: *Psenopsis*: 5.9 ppb (3); *Epineplelus merra*: 41 ppb (2)

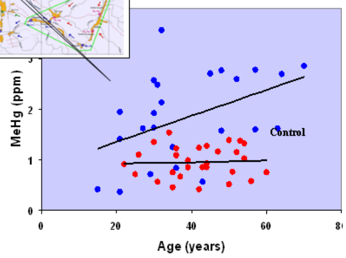


RESULT 4: MeHg (ppm) in Scalp Hairs



Talawaan Bajo	
N	25
avg	1.84
std	0.87
min	0.36
max	3.57
CI (95%)	0.35

Bajo (Control)	
N	29
avg	0.95
std	0.31
min	0.41
max	1.54
CI (95%)	0.12



CONCLUSIONS

- Hg from artisanal gold mining was emitted to the environment
- Hg was methylated in the sediment of Riverine system of Talawaan Watershed
- Hg was accumulated in sediment and fish in various levels
- Although, the levels of mercury concentration in every environmental sample in the present study were lower than the standard values, the mercury is potentially accumulated in the residents through food web at the remote area from the mining place
- More detailed studies are necessary in order to evaluate further impact to the residents, though

Acknowledgement

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- Dr. Kazuko Kamiya, *Director-General of NIMD*
- Dr. Mineshi Sakamoto, *The chair of this Special Session*

Mercury, selenium, PCBs and fatty acids in fresh and canned fish on the Slovenian market

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Although fish are an important source of essential nutrients, they are also a source of pollutants such as mercury (Hg) and polychlorinated biphenyls (PCBs). Hg, PCBs, selenium (Se) and n-3 fatty acids were determined in fresh and canned fish samples from the Slovenian market. Based on the results of the study of the EU funded project PHIME, mercury exposure of pregnant women in Slovenia was also assessed.
52 fresh and 76 canned fish samples were bought on the Slovenian market. The analyses of total mercury (THg) and total selenium content (TSe) were performed in all the samples, while the analyses of fatty acid composition and PCBs were performed on 20 and 51 fish samples, respectively. THg was determined by chemical digestion and atomic absorption spectrometry using cold-vapor atomic absorption spectrometer (CVAAS). Chemical digestion and hydride generation atomic fluorescence spectrometry (HG-AFS) was used for TSe determination. For identification and quantification of n-3 acid we used the *in situ* transesterification method and gas chromatography-flame ionization detection (GC-FID). Seven "indicator polychlorinated bipenyls" (congeners 28, 52, 101, 118, 138, 153 and 180) were extracted by the Soxhlet method, lipids were removed by concentrated sulfuric acid and the florisil column was used for cleaning-up. The PCBs were identified and quantified by gas chromatography-electron capture detection (GC-ECD).
The median values of important nutrients in fish were 421 ng/g for TSe and 259 mg/100g for n-3 fatty acid and the median values of pollutants were 80 ng/g for THg and 4 ng/g for PCBs. Based on THg concentrations in hair of pregnant women (Me=306 ng/g) and fish consumption assessed by food frequency questionnaires, the linear regression correlation was calculated ($R=0,318$, $p < 0,001$). The weak correlation could be due to low THg concentrations in hair and high variability of THg concentrations in fish.
The weakly dietary intake of MeHg, ingested by 95% of Slovenian pregnant women, calculated from THg concentrations in hair, does not exceed the current EPA reference dose. Based on the present study, it can be concluded that the levels of MeHg and PCBs in fish, consumed on average 1-3 times per month, do not represent a health risk and that fish are an important source of selenium and n-3 fatty acid.

Methyl mercury and Omega-3 PUFA exposure from fish consumption among communities near Ethiopian Rift Valley Lakes (ERVLs): *on going project*

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Abstract: Fish is an important component of the diet in Ethiopia and it is an excellent source of important nutrients. Yet, such benefits may be offset by the presence of contaminants such as, methylmercury (MeHg). Our objective is to investigate MeHg exposure levels and nutritional benefits from fish consumption in communities near ERVLs. This research involves three phases: Phase I was focused on the assessment of fish consumption pattern and major health problems of the population, which was conducted using a structured food frequency questionnaire. Phase II will focus on MeHg and n-3 polyunsaturated fatty acids (n-3PUFAs) exposure assessments and Phase III is planned to involve a cohort study of child development. The diets of the study population are dominated by a single staple food and the source of animal proteins for most of the study population, for instance, for 100 % of Arbamich and 82.1 % of Zeway fishermen was fish only and they never ate other animal proteins. There are six important fish species landing in the study areas. (Tilapia) *O. niloticus* consumption rate in Zeway, Awassa and Arbaminch is 81.1 %, 78 % and 79.3%, respectively. Catfish and Barbus species are the second and the third most frequently consumed species next to tilapia. Mean fish meal consumption rate in the study population per week was 8.5 (range 1- 14 meals). Half (47.9%) of the population had 10 to 14 meals per week. The average weekly fish meal consumption was significantly different among fishermen in Arbaminch, Zeway and Awassa (13.5, 10.2 and 9.5 respectively $P< 0.01$). Mean amount of fish consumption per week per individual was 1309g (range 125g - 3500g per week). In the health status survey, Mental illness was reported as their major family health problem by 24.5 % of households from Zeway islands.. Therefore, the second phase will focus on the assessment of MeHg and n-3PUFA exposure among fishermen and their families living around these lakes.

Key words: Ethiopian Rift Valley Lakes; Fish consumption; Methylmercury; Polyunsaturated fatty acid.

Introduction: Fish is an important component of the diet in Ethiopia where about 49% of the total population is considered 'under-nourished' (FAO, 1995). Estimated annual fish yield potential of the country is about 51,000 tonnes (Mebrat, 1993). Aquatic food chains are capable of accumulating certain environmental contaminants up to toxic concentrations. MeHg is the most dramatic and best documented example of high bioaccumulation (Clarkson, 1995).Hg concentration was reported from one of the rift valley lakes, Lake Awassa. The Hg concentration in the effluent discharged to and the concentration in the water from Tikur Wuha is 5.1µg/l and 2.8µg/l (Zinabu and Pearce, 2003). Desta *et al* (2006) reported the high mercury concentration in piscivorous Big Barbs (*Barbus intermedius*) in Lake Awassa. The level of Hg was beyond the marketing limit of the European Union (0.5 mg/kg) and FAO/WHO's guideline for safe fish consumption (0.3 mg/kg).

Communities living around these lakes have a long history of relying upon fish as a major part of thier diet and using fish for commercial fisheries. Compared to other group of populations, fishermen and thier families may eat more and variety of fish. Yet, nothing is known about the exposure level as well as health effects caused by contaminants through fish consumption. The purpose of this study is therefore to investigate MeHg exposure levels and nutritional benefits from fish consumption in communities near ERVLs. This study involves three phases:

Methods: Phase I: The study area includes fish landing sites and surroundings at lakes situated in the southern part of the Ethiopian rift valley.. This cross- sectional study involved questionnaire administration completed by each participant. The questionnaire was designed using (UNEP DTIE, 2008) guideline. Fish weight estimation and species identification were performed with the help of staffs from Ethiopian Fish Production and Marketing Corporation (EFMPC). The study was approved by ethics committee of Addis Ababa University.

Phase II: To assess exposure to mercury, hair and blood samples will be collected from fishermen families and children who are working as assistants to the fishermen. We will also determine plasma polyunsaturated fatty acid concentrations of the study population. In addition, Fish samples from different species will be used for chemical analysis including mercury and fatty acid concentrations.

Phase III: Since fetus is a highest risk group for MeHg exposure. At the third stage, we are also going to collect the samples from pregnant women and fetuses (cord blood) for the future cohort study of child development.

Results and Discussion: The total number of households surveyed was 307, consisting of 184 in Zeway Islands 69 in Arbaminch and 54 in Awassa. In addition, 133 fishermen and 21 children working as assistants were surveyed at fishing sites.

The diets of the study population are dominated by a single staple food such as cereals with some vegetables such as cabbage or tomato. Overall, the mean number of fish meals eaten per week by the whole population was 8.5. The source of animal proteins for most of the study population, for instance, for 100 % of Arbamich fishermen and 82.1 % of Zeway fishermen was fish only and they never ate other animal proteins.

There are six important fish species landing in the study areas. The dominant species was (Tilapia) *Oreochromis niloticus.* Tilapia was the most frequently consumed fish followed by Catfish and Barbus species in all study areas. The mercury concentrations of piscivorous big barbs, O. *niloticus* and *C. garipinus* from *lake* Awassa were 0.01to 0.94mg/kg; 0.0028 and 0.082 mg/ kg and 0.002–0.154 mg /kg respectively (Desta et al., 2006). Since the mercury concentration of the big Barbu species was beyond FAO/WHO's guideline for safe fish consumption, it may pose a health risk to those people who frequently consumed this species.

Mean fish meal consumption rate in the study population per week was 8.5 (range 1- 14 meals). Half (47.9%) of the study population had 10 to 14 meals per week. The amount of fish consumed per week by the study population ranges from 125g to 3500g. The mean fish consumption rate by the whole population was 1309g/week.

The estimated fish consumption rate by the study population (63kg/year) was more than 6 times higher than the amount of fish consumed by the local people living in the areas such as, Arbaminch, Sodo and Awassa (8.5kg/year) and in Gambella, close to River Baro (10kg/year) (FAO, 1995). It was also exceeds the estimated total per capita fish consumption of Sub-Saharan Africa (6.7kg/year) as well as per capita consumption of most developing countries (14kg/year) (Delgado, et al., 2003). In Ethiopia, extreme regional variation in fish consumption was reported (René, 1991).

Since there is no fish consumption advisory in Ethiopia and / or in the absence of data regarding the levels of toxic pollutants in various fish species, it is difficult to judge whether their fish consumption pattern exposed them to toxic pollutants such as MeHg or not.

The study populations in all study areas had complaint for infectious diseases that are very common in Sub Saharan African countries. But unique to population from Zeway islands, Mental illness was reported as their major family health problem by 24.5 % of the households. In the previous study, a relatively high prevalence of mental illness (1.8% of Bipolar disorders and 0.06% schizophrenia) among Zay people was reported (Abebaw *et al*., 2004). In contrast with several studies that showed the association of greater seafood consumption with lower prevalence of bipolar disorders (Hibbeln 1998; Noaghiul and Hibbeln 2003), a relatively high prevalence of bipolar disorder was observed in our population who consume more than 10 fish meals and on the average 1344g of fish per week. Even this prevalence of mental illness was significantly higher compared to the prevalence observed among non fish eating communities of Ethiopia (Kebede and Alem, 1999).

In conclusion, Phase I of the present research showed that fishermen and their families living around ERVLs solely rely on fish to cover their daily proteins. The most frequently consumed fish species was Tilapia followed by Catfish and Barbus species. Mental illness was identified as a serious health problem by many people interviewed on the two Zeway islands. Therefore, the Second phase of the research will focus on the: 1) Determination of the levels of MeHg and n- 3PUFAs contents of frequently consumed fish species.2) Assessment of both MeHg and n-3PUFAs exposure level of the study population. 3) Association of frequent fish consumption and prevalence of mental illness among Zeway fishermen.

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Mercury levels in household members hair and in fish from fishing villages in Zhoushan, China

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Abstract
In order to assess the potential health risks associated with dietary consumption of mercury, hair samples from 59 piscatorial households and thirteen species of fish samples were collected from the fishing villagers of Zhoushan. Total Mercury (T-Hg) and methylmercury (MeHg) concentrations in the fathers' hair (mean, 5.7 and 3.8 μg/g) were approximately 2.5 and 2.1 times greater and 2.6 and 2.0 times higher than those of their wives (2.3 and 1.8 μg/g) and their children (2.2 and 1.7 μg/g), respectively. However, the mean quantity of the fish consumed by the fathers was 2.5 and 2.4 times higher than those of the mothers and children, implying that there was a wide variation in hair Hg concentrations between the fathers and the mothers and children of the same household, which was probably related to the quantity, frequency and type of fish consumed. The average T-Hg and MeHg concentrations in all species of fish were 0.26 and 0.18 μg/g, respectively. Approximately, 15% and 19% of the samples showed T-Hg and MeHg levels which exceeded the limit established by the Chinese National Standard Agency (CNSA) (0.3 and 0.2 μg/g), respectively. The highest daily intakes for T-Hg (0.87 μg/kg/day) and MeHg (0.84 μg/kg/day) from fish were detected in the fishermen, followed by their children (057 μg/kg/day of T-Hg, 0.55 μg/kg/day of MeHg) and their wives (0.41 μg/kg/day of T-Hg, 0.39 μg/kg/day of MeHg). Further study will be needed to examine for pregnant women.
Keywords: Fishermen, household members， mercury, Zhoushan

1. Introduction
Zhoushan Island is situated on the coast of the East China Sea, near Hangzhou and Shanghai. The offshore area is an important fishing ground, where the total length of the continental coastline is 1500 km and the total sea area of the fishing ground is about 100 000 km^2. The annual fish catch is about 800 000 t, representing one third of the Chinese national total (Jiang et al., 2005). Seafood dominates the diet of the Zhoushan coastal populations, and includes many species of fish and shellfish, as well as a variety of other invertebrates. According to the dietary survey of Jiang et al. (2005), a healthy adult in the coastal city of Zhoushan consumed 105±182 g fish meat each day which is greater than the average rate of consumption of marine products in China as a whole (23 g/person per day). Our previous studies showed that hair Hg levels in subjects from Zhoushan City were higher (mean 2.44 μg/g for males and 1.94 μg/g for females) than the levels found in hair samples from subjects in Shanghai, Ningbo, Dalian and Xiamen districts (Liu et al., 2008). This study aims to assess Hg exposure by measuring total mercury (T-Hg) and methyl mercury (MeHg) in the hair of fishermen and their household members in Zhoushan fishing village.
Factors such as the quantity of fish consumed, age, gender and Hg levels in fish were investigated.

2. Materials and Methods
Hair samples were collected from 59 piscatorial households (n=166 household members) in the fishing village of Zhoushan Island, China. The selection of households for the study was based on fishing villagers, especially those engaged in fishing professionally for more than 2 years. Of the 166 individuals, 59 were fishermen (fathers, aged from 25-50 years), 59 were housewives (mothers, aged from 23-50 years) and 48 were children (male 27, female 21, In order to estimated dietary intakes, the age of children were selected from 2-7 years). For each volunteer, the quantity of fish consumed each day was recorded. The individual dietary consumption of thirteen species of fish, representative of the species commonly consumed in the area, was examined for the fishermen, housewives and children, respectively. For fishermen, the number of fishing days per month was also recorded. Thirteen types of fish (n = 148), representative of the fish commonly harvested and consumed by the fishermen were purchased from the fishermen. Fish length and weight were measured and recorded before dissection.

T-Hg and MeHg concentrations in the samples were analyzed using cold vapor atomic adsorption spectrometry and gas chromatography with electron capture detector, respectively, according to the method of the Japanese National Institute for Minamata Disease (NIMD) (NIMD, 2001).

The daily intake (DI) of Hg were determined according to the following formula:

$$DIs = \Sigma (DM_{fish} \times C_{fish}) / Wt \quad \textbf{(1)}$$

Where: DM: Daily meal quantity of every type of fish (g/day). In this study thirteen species of commonly consumed fish were examined for individual dietary consumption. C: The mean levels of T-Hg and MeHg in every type of fish (μg/g). Wt: Body weight. For the calculations, the absorption efficiencies of Hg species in the diet by humans were considered to be approximately 8% for inorganic Hg (I-Hg) and 95% for MeHg, respectively. I-Hg concentrations were the difference between T-Hg and MeHg concentrations.

3. Results and Discussion
The mean T-Hg and MeHg concentrations in the hair samples were 5.7 and 3.8 μg/g, respectively, for fathers, 2.3

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and 1.8 μg/g for mothers, and 2.2 and 1.7 μg/g for children.

Mean T-Hg and MeHg concentrations in the fathers' hair were approximately 2.5 and 2.1 times greater than the concentrations in their wives' hair, and 2.6 and 2.0 times higher than the concentrations in their children's hair. Mean T-Hg and MeHg concentrations in the hair of mothers (2.3 and 1.8 μg/g) were higher than those of girls (1.9 and 1.4 μg/g), and lower than those of boys (2.4 and 1.9 μg/g), however, these differences were not statistically significant (P>0.05). Furthermore, Pearson's correlation coefficient studies showed that a weak but significant positive correlation in Hg concentrations was observed between the mothers and children, whereas no significant correlation was observed between the fathers and the mothers and children. A wide variation in hair Hg concentrations was observed between fathers and mothers and children of the same household which was probably related to the quantity, frequency and type of fish consumed.

Hair Hg concentrations in boys was higher than that of girls, however, no significant gender difference was found (p>0.05). No statistically significant correlation was observed between T-Hg or MeHg and age of the fathers and mothers. However, a weak but significant positive correlation between T-Hg or MeHg concentrations in hair and age was observed in children (boys and/or girls) and all household members.

T-Hg and MeHg in all fish samples were measured on a wet weight basis and ranged between 0.01 μg/g and 0.0004 μg/g, which was found in a specimen of *Monopterus albus* (mean = 0.13 and 0.09 μg/g respectively), to 0.66 and 0.59 μg/g found in *Argyrosomus argentatus* (mean = 0.33 and 0.19 μg/g, respectively). The average T-Hg and MeHg concentrations in all species were 0.26 and 0.18 μg/g, respectively. Approximately 15% and 19% of the samples showed T-Hg and MeHg levels which exceeded the limits established by the Chinese National Standard Agency (CNSA, 1994) (0.3 and 0.2 μg/g, respectively).

The highest DI for T-Hg (0.87 μg/kg/day) and MeHg (0.84 μg/kg/day) were detected in the fishermen, followed by their children (057 μg/kg/day of T-Hg, 0.55 μg/kg/day of MeHg) and their wives (0.41 μg/kg/day of T-Hg, 0.39 μg/kg/day of MeHg). The DI varied in the mothers and children, due to differences in ingestion rate and body weight. MeHg intake for fishermen, housewives and children greatly exceeded the tolerable exposure limit for pregnant women by US EPA (2001, 0.1μg/kg/d), JECFA (2003, 0. 23 μg/kg/d) and Japanese Ministry of Health, Labour and Welfare (JHLW 2005, 0.29μg/kg/d).

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Health benefits and chemical risks associated to dietary habits: Fish consumption, mercury and omega-3 fatty acids

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Abstract
We determined the concentrations of EPA and DHA, as well as those of a number of chemical contaminants, including mercury (Hg) in 14 edible marine species. To quantitative establish the intake of these pollutants (risks) versus that of EPA + DHA (benefits), we designed a simple software, RIBEPEIX (http://www.fmcs.urv.cat/portada/ribepeix/). The concentrations of EPA, DHA, and chemical pollutants were used as database of the program. Although it seems quite evident that fish must be an important part of a balanced diet, to choose the most suitable species in terms of levels of PUFAs and pollutants, with special attention to Hg, the frequency of consumption, and the meal size are essential aspects to balance benefits and risks of a regular consumption of fish and seafood. RIBEPEIX may be used as easy tools to optimize the dietary habits of any subject by increasing the intake of beneficial nutrients and by reducing those of toxic pollutants, including Hg. It can be useful not only for professionals (cardiologists, general physicians, nutritionists, endocrinologists, toxicologists, etc.), but also for the general population, it is available (free) in Internet.

Keywords: mercury, fish, seafood, ingestion, risks, benefit

1. Introduction

In recent years, and based on the importance of fish as a part of a healthy diet, there has been a notable promotion of fish and seafood consumption. For cardiovascular risk reduction in the general population, prestigious institutions such as the American Heart Association have suggested, among other dietary recommendations, to consume fish, especially oily fish, at least twice a week. Oily fish are rich in omega-3 polyunsaturated acids (PUFAs) such as EPA (eicosapentaenoic) and DHA (docosahexanoic), which have shown to have protective effects in preventing coronary heart disease among other important health benefits. However, recent studies have also shown that fish consumption might also mean a potential source of exposure to various chemical pollutants.

Recently, we have measured the levels of different organic and inorganic pollutants, with special attention to Hg, together with the concentrations of EPA, DHA in samples of the 14 most consumed fish and seafood species (sardine, tuna, anchovy, mackerel, swordfish, salmon, hake, red mullet, sole, cuttlefish, squid, clam, mussel and shrimp) in Catalonia, Spain (Domingo et al. 2007). All the data generated were introduced into a program called RIBEPEIX which may be used as an easy tool to optimize fish consumption: most suitable species, frequency of consumption, and size of meals.

2. Design of the RIBEPEIX computer program

To quantitative establish the intake of pollutants (risks) versus that of EPA and DHA (benefits), a simple computer program, RIBEPEIX was designed. RIBEPEIX (http://www.fmcs.urv.cat/portada/ribepeix) is structured in various screens to which the user gets access by means of different icons.

2.1. Main screen

The weight, age, and sex of the user are requested, but only body weight is an obligatory field.

2.2. Data screen

The user must here include, for each of the 14 selected fish and shellfish species, his/her weekly frequency of consumption and the approximate meal size (227, 113.5, or 56.75 g). In the lower part of this screen, two icons to be potentially clicked can be found. Clicking these icons, two screens show then risks (intake of pollutants) and benefits (intake of EPA+ DHA), respectively. An icon offering the possibility to go back in order to modify the consumption data is also included.

2.3. Risks screen

The detailed intakes corresponding to each pollutant for the specific user are here shown. They are based on the respective body weight, the weekly fish consumption, and the meal size. The tolerable/admissible intake concerning each pollutant is also shown for those contaminants for which information is available. For those contaminants in which a red symbol appears, the tolerable weekly intake is being surpassed. Finally, clicking on the question mark concerning each contaminant a brief summary of information about this pollutant can be found. This can be especially important for those individual who are not very familiarized with the chemistry, environmental distribution, and toxicity of certain contaminants.

2.4. Benefits screen

The intakes corresponding to EPA and DHA are here shown. The recommendations performed by international organisms are also included for different situations, i.e., healthy subjects, individuals with CHD, pregnant women, etc.

2.5. "Making changes in your usual fish consumption" screen

According to the results concerning risks and benefits of a particular fish consumption habit, an individual can then decide to optimize the balance between risks and benefits. In this screen, the most and the less polluted fish and shellfish species are detailed, as well as the species with the highest and lowest contents of EPA plus DHA.

With this information, the user can modify his/her fish consumption habits in order to reduce the risks by exposure to chemical contaminants and to increase his/her intake of PUFAs. All screens can be printed for making easier to visualize the results of changing the fish consumption habits.

3. Results and Discussion

Fish consumption at least twice a week, is one of the main dietary recommendations. However, it is evident that most recent studies supporting this recommendation did not sufficiently consider the potential risks associated derived from fish and shellfish consumption. Some investigations have shown certain doubts regarding this general statement. With respect to mercury, which has been probable one of the most investigated chemical contaminants in edible marine species, it has been reported that dietary fish might be protective or harmful, depending on its contents of omega-3 fatty acids and mercury (Salonen et al. 1995). Other studies did not find an association between total mercury exposure and the risk of CHD, but these authors remarked that a weak relation could not be ruled out Yoshizama et al. (2002). In turn, Cohen et al. (2005) suggested that substitution of fish with high methylmercury concentrations by fish containing les methylmercury among women of childbearing age yielded substantial developmental benefits and few negative impacts.

In our study, swordfish showed the highest mercury levels, while clam, mussel, cuttlefish, and salmon were the species with the lowest concentrations of this element. Therefore, the specie seems to be one of the important factors to be contemplated when balancing risks and benefits. Using RIBEPEIX, it can be seen that the potential cardiovascular benefits presumably derived from the intake of omega-3 fatty acids may be clearly counteracted by the potential risks related to the exposure to certain contaminants, which can exceed the tolerable intakes.

In summary, fish consumption is recommended taking into account species and amounts to minimize health risks while optimizing health benefits. The health risks directly derived from the concurrent exposure to chemical pollutants must be also taken into account. For it, RIBEPEIX can be used as a useful tool to improve the balance between benefits (omega-3) and risks (contaminants) of fish consumption.

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