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Mercury concentration and fish consumption in Taiwanese pregnant women

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Objective The aim of this study was to assess the relationship between fish consumption and total mercury concentration in maternal blood, umbilical cord blood, and placenta tissue of pregnant women in Taiwan.

Design Cross-sectional study.

Setting A medical centre in Taipei, Taiwan.

Sample Sixty-five pregnant women delivered between July 2004 and March 2005.

Methods We administered a questionnaire to each woman in the third trimester and collected blood samples and placenta tissue after delivery. Mercury concentrations in the maternal blood, cord blood and placenta tissue were measured using mercury analyser (Hiranuma HG-310, Hitachi, Japan). A dietitian calculated the quantity of fish consumed from the questionnaire.

Main outcome measures The total mercury concentration in maternal blood, cord blood and placenta tissue.

Results The mean total mercury concentration in maternal blood, cord blood and placenta tissue was 9.1 ± 0.40 microgram/l, 10.0 ± 0.55 microgram/l and 19.2 ± 1.8 ng/g, respectively. Eighty-nine percent of the maternal blood mercury concentrations exceeded the US National Research Council recommended value of 5.8 microgram/l. Fish consumption while pregnant correlated significantly with maternal blood and cord blood mercury concentrations.

Conclusions Total mercury concentrations of maternal blood, cord blood and placenta tissue commonly exceeded recommended values, and were higher in women who ate fish more than three times a week while pregnant.

Keywords Fish consumption, mercury, pregnant women, Taiwan.

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Introduction

Mercury is an environmental toxicant found in the aquatic ecosystem. It accumulates in fish and other marine species to varying degrees, particularly in long-living predators that are at the top of the marine food chain.[1] People consuming large amounts of contaminated seafood may have elevated concentrations of heavy metals in their tissues compared with the general population.[2–5] Several studies have shown a correlation between blood mercury levels and methylmercury exposure through fish consumption.[6–8]

An association has been reported in some fish-eating populations between the levels of maternal mercury exposure during pregnancy and developmental delays in their children. The fetus is most susceptible to mercury exposure during organogenesis, with reported neuronal, kidney and brain damage and growth restriction.[9] Despite these risks, fish is an important part of a healthy diet due to its high-quality protein and other essential nutrients, so it is important that it is included in the diets of women and young children.[10]

Taiwanese commonly eat fish at three or more meals per week, a level of consumption that increases with age.[11] Several studies indicate that high fish consumers eat fish at 3–4 meals per week, while the highest consumers eat fish at 6–8 meals per week. Although Taiwan is a high fish-consuming country,[12] very little information is available on the accumulation of mercury in pregnant Taiwanese women.

To assess the risk of mercury toxicity in Taiwanese women, information is needed on the likely route of exposure. We therefore assessed the relationship between maternal fish consumption and total mercury concentration in maternal blood, umbilical cord blood and placenta tissue of pregnant women in Taiwan.

Methods

A total of 65 pregnant women residing in the city of Taipei were recruited for the study. They were recruited in the third trimester (after 24 weeks), and all delivered at a single medical centre between July 2004 and March 2005. After obtaining written consent, a trained interviewer conducted a face-to-face interview in which information on the woman's sociodemographic characteristics, occupation, pregnancy and reproductive history, fish intake and other lifestyle characteristics were collected. The gestational age was calculated on medical history.

Following delivery, blood samples were collected from the mother and umbilical cord in 10 ml EDTA tubes, together with the placenta. The experimental method was modified from Tseng *et al.*[13] The samples of blood and placenta tissue were prepared as follows: 0.5 ml of the EDTA blood or 0.5 g placental tissue was acid digested with a solution containing 0.1 g $K_2S_2O_8$ and 2 ml HNO_3. After wet digestion at 90°C for 30 minutes, the samples were cooled in a refrigerator at 4°C. After cooling, the residue fluid was diluted to 10 ml with 3% HCl.[13,14] The mercury concentration was analysed using a mercury analyser (Hiranuma HG-310, Hitachi, Japan).

Each sample was analysed in triplicate. Standard reference material Seronorm™ (SERO, Billingstad, Norway) Trace Elements Whole Blood Level 2 (MR9067) was used to perform a standard material test to ensure the precision and accuracy of the analyses. The precision was 3.8%, and the accuracy was 102.1%.

The distributions of continuous variables were expressed as mean ± standard error . Paired *t* tests compared differences in mercury concentrations between maternal blood and cord blood, and we used Spearman's correlation to test the association between mercury concentration and frequency of fish consumption. Analysis of variance was used to assess the independent effects of multiple categorical variables. Results were considered significant in a two-sided test if $P < 0.05$.

Results

The demographic characteristics of the 65 mothers are summarised in Table 1. The mean age of this population was 30 years, and the mean body mass index before pregnancy was 21 kg/m^2. Very few of the mothers smoked cigarettes (6.2%) or used alcohol (1.5%) while pregnant. The proportion of subjects who ate fish increased during pregnancy (95% before pregnancy versus 99% while pregnant). The amount of fish consumed increased from 8 meals per month before pregnancy to 11 meals per month while pregnant.

The mean mercury concentration in maternal blood and cord blood was 9.1 ± 0.40 and 10 ± 0.55 microgram/l, respectively, while the mean placenta mercury concentration was 19 ± 1.8 ng/g (Table 2). Mercury concentrations were significantly higher in the cord blood compared with maternal blood (10 ± 0.55 microgram/l versus 9.1 ± 0.40 microgram/l, respectively; $P < 0.05$). We found that the average cord/maternal blood mercury concentration ratio was 1.1 ± 0.03 (0.50–1.8). Approximately 89% of the maternal blood mercury concentrations exceeded the US National Research Council (USNRC) recommended the value of 5.8 microgram/l (Figure 1).[15]

Correlations between mercury concentration and fish consumption frequency are shown in Table 3. There were significant, positive correlations between maternal blood, cord blood and placenta tissue mercury concentrations. Maternal blood mercury concentrations did not correlate with age or parity (data not shown). Fish consumption while pregnant correlated significantly with maternal blood and cord blood

Table 1. Demographic characteristics of pregnant women ($n = 65$)

Characteristic	Mean (range)	SD	*n* (%)
Age (years)	30 (16–42)	4.7	
Height (cm)	160 (150–176)	5.4	
Prepregnant weight (kg)	52 (38–84)	7.7	
Perinatal weight (kg)	67 (53–106)	9.0	
Prepregnant BMI (kg/m^2)	21 (17–32)	2.7	
Perinatal BMI (kg/m^2)	26 (21–41)	3.2	
Increment of BMI (kg/m^2)*	5.8 (2.6–12)	1.7	
Fish consumption prior to pregnancy (times/month)	8.1 (0–28)	8.4	
Fish consumption while pregnant (times/month)	11 (0–28)	9.6	
Smoked while pregnant			4 (6.2)
Drank alcohol while pregnant			1 (1.5)
Tooth filling present			47 (72)
Regular gum chewing			46 (71)
Occupational exposure (worked in dental clinic)			4 (6.2)

BMI, body mass index.
*Increment of BMI = (perinatal BMI) − (prepregnant BMI).

Table 2. The concentrations of total mercury in maternal blood, umbilical cord blood and placenta tissue

	n	Mean ± SE (range)	Median	Geometric mean
Maternal blood (microgram/l)	65	9.1 ± 0.40 (4.4–21)	8.3	8.6
Cord blood (microgram/l)	65	10 ± 0.55 (3.8–28)	9.1	9.2
Placenta (ng/g)	46	19 ± 1.8 (6.2–81)	18	17

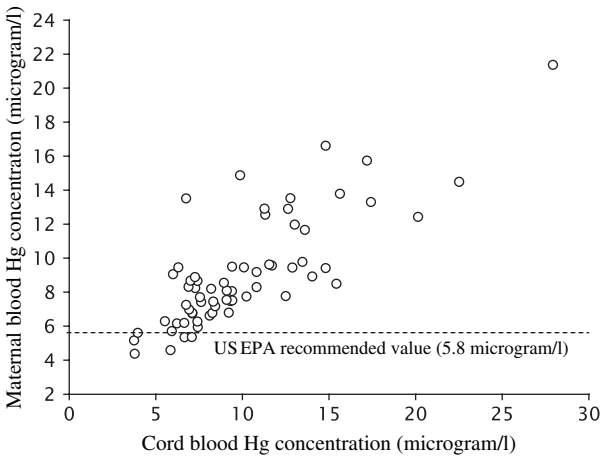

Figure 1. Distribution of individual maternal blood mercury concentrations comparison of USEPA recommend value (5.8 microgram/l). Hg, mercury.

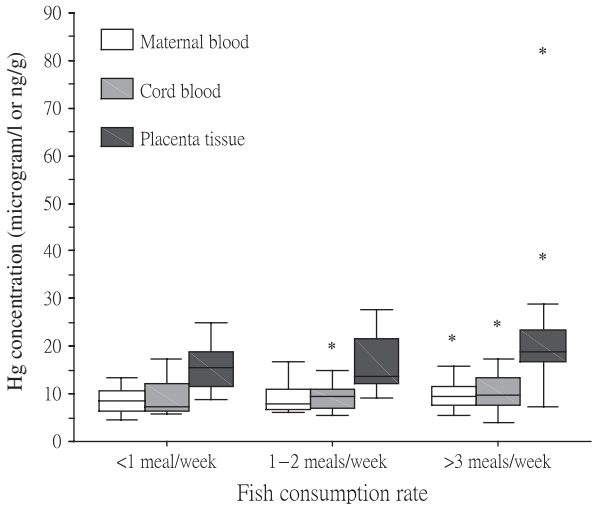

Figure 2. Box and whisker plots display the distributions of the total mercury concentrations in maternal blood, cord blood (microgram/l) and placenta tissue (ng/g) among different fish consumption rate at pregnant (*, outlier; **, extreme outlier). Hg, mercury.

mercury concentration (but not placental mercury). In contrast, fish consumption prior to pregnancy was significantly correlated with placental tissue mercury concentrations, but not with maternal or cord blood concentrations.

Figure 2 shows box and whisker plots of mercury concentrations in maternal blood, cord blood and placenta tissue for different quantities of fish consumed while pregnant. Although mercury concentrations increased with increasing frequency of fish consumption (<1 meal/week, 1–2 meals/week, >3 meals/week), the differences between the three groups were not statistically significant.

Discussion

In this study, we determined the mercury concentrations in maternal blood, cord blood and placenta tissue of Taiwanese women. The mercury concentrations found in our study are comparable with other studies. For example, in a Spanish study, Soria *et al.*[16] found average mercury concentrations of 5.0 microgram/l, 5.3 microgram/l and 5.4 ng/g in maternal blood, cord blood and placental tissue, respectively. In pregnant women in Canada, whose average fish consumption was six times per month, Joelle *et al.*[17] found the mean mercury concentrations in maternal blood and cord blood to be 0.5 and 0.5 microgram/l, respectively. Although this was much lower than the concentrations found in our study, our women consumed nearly twice as much fish during their pregnancy. In general, we found that fish consumption was higher in our study than other countries. This difference may occur because traditionally in the Chinese diet, pregnant women eat fish to provide better nutrition for the fetus. Fish consumed during pregnancy is therefore a major source of bioaccumulated mercury.

In 2000, the USNRC concluded that cord blood mercury concentrations exceeding 58 microgram/l influenced neural development of the fetus. To provide for variations in race and individual health, and with an uncertainty factor of 10, the recommended upper limit was placed at 5.8 microgram/l. In 2003, the US Environmental Protection Agency (USEPA) adopted this value as the standard value to monitor the

Table 3. Correlation between mercury concentration and fish consumption frequency (Spearman's rank correlation)

	Maternal blood	Cord blood	Placenta	Fish consumption prior to pregnancy	Fish consumption while pregnant
Maternal blood	1.00	0.75**	0.86**	0.24	0.25*
Cord blood		1.00	0.83*	0.21	0.32**
Placenta			1.00	0.24*	0.28
Fish consumption prior to pregnancy				1.00	0.75**
Fish consumption at pregnancy					1.00

*$P > 0.05$; **$P < 0.01$.

mercury concentration in the blood. Schober *et al.*[15] analysed data from the 1999–2000 US National Health and Nutrition Examination Survey (NHANES) and found that 8% of US women had total mercury concentrations that exceeded the USEPA's recommended value. Analysing NHANES data from 1999 to 2002, the US Centres for Disease Control and Prevention[18] found that 6% of blood mercury concentrations in women of childbearing age was more than 5.8 microgram/l. A substantially higher proportion of women in our study had elevated blood mercury levels. It is likely that the higher mercury concentrations are due to diet and possibly to other factors (e.g. race). Methylmercury is the most common form of mercury found in fish. After ingestion of the fish, it is absorbed in the gastrointestinal tract and rapidly enters the blood[19], with nearly 95% stored in red blood cells. Within 3 days, it is spread throughout the body, with the brain being the prime target organ. In a pregnant woman, methylmercury passes through the placenta to the fetus. Its concentration in cord blood is usually higher than in maternal blood due to its high affinity for fetal haemoglobin.[20,21] Amin-Zaki *et al.*[22] showed that the concentration of methylmercury in fetus' blood was 25% higher than in the maternal blood. Even though our study did not specifically analyse the concentration of methylmercury, the total mercury content of cord blood was about 11% higher than in maternal blood. The placental concentrations were even higher. This occurs because of the placenta's function of protecting the fetus from infections and potentially harmful substances by retaining toxins.

Our results provide essential information regarding the impact of the mother's consumption of fish on mercury levels. The US Food and Drug Administration and the USEPA are advising pregnant women, nursing mothers and young children to avoid eating fish that contain high levels of mercury such as shark, swordfish, king mackerel and tilefish. Instead, they recommend that these groups eat up to 340 g/week of a variety of fish and shellfish that are lower in mercury such as shrimp and tilapia.[10] We recommend that the government conduct a large-scale survey to ascertain mercury concentrations in the blood of pregnant women and women of childbearing age in Taiwan. Such information may lead to a reduction in consumption of high mercury-containing fish and subsequently diminish possible adverse health effects to mothers and fetuses.

Our finding of a higher average ratio of cord to maternal blood may be explained by placental function and also by changes in the mother's diet.[23] It also suggests that cord blood may be a better biological marker of uterine exposure than maternal blood. High cord blood mercury levels may indicate that the fetus has a greater mercury exposure than the mother, a risk that deserves further investigation.

Previous studies found that occupational exposure, environmental pollution, drinking, teeth fillings, traditional Chinese medicine, nutrient and fish intake were all factors that influence mercury levels.[24–34] Although aware of these factors, our limited sample size and the fact that only four of our subjects had occupational exposure and only one expectant mother consumed alcohol did not allow us to investigate other risk factors. Although 72% of mothers had tooth fillings, there was no correlation between tooth fillings and body mercury burden. This may be due to changes in tooth filling materials and the decreasing use of dental amalgam. This finding supports that of Akesson *et al.*[35] and Langworth *et al.*[36] who also found that blood mercury concentrations correlated highly with fish consumption, but not with tooth fillings.

Conclusion

Blood total mercury concentrations frequently exceed recommended levels in pregnant woman in the city of Taipei. The elevated mercury levels correlated significantly with fish consumption. The high mercury concentrations found in pregnant women in Taipei are a cause for concern due to the known fetal adverse effects. Cord blood is more suitable for use as a biological marker of uterine exposure index than maternal blood due to its accumulation in the placenta and fetus.

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