Maternal Methylmercury Exposure Through Rice Ingestion and Offspring Development: Preliminary Results

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1. BACKGROUND & SIGNIFICANCE

- Mercury is a global pollutant and potent neurotoxin; methylmercury is one of the most toxic form of mercury, which most severely afflicts the developing fetus. Intake of fish is regarded as the primary methylmercury exposure pathway (Clarkson and Magos, 2006).
- Flooded rice paddies are important mercury methylation sites, where methylmercury is bioaccumulated in rice grain (Rothenberg et al., 2011a; Rothenberg and Feng, 2012). In some regions in southwestern China, rice ingestion is more important than fish consumption for methylmercury exposure (Zhang et al., 2011, Rothenberg et al., 2011b, 2013). However, rice does not contain the same beneficial micronutrients as fish (e.g., omega-3 fatty acids), which promote neurodevelopment. Therefore exposure to methylmercury through rice ingestion may be more toxic compared to fish ingestion.
- The major aim of this study is to establish for the first time the relationship between prenatal methylmercury exposure and offspring development in a population where rice is the primary maternal methylmercury exposure pathway.

2. METHODS

- We are working in a rural area of Guangxi province, China, where rice is a staple food (Figure 1)
- Phase 1 (completed): Between May 2013 and March 2014, a total of 400 healthy pregnant women were recruited at parturition. After providing informed consent, mothers donated hair and blood samples, a rice sample from their home, and filled out a 4-part questionnaire. Fish tissue was collected from local markets, and included common fish species consumed by residents.

Figure 2. BSID-II assessment

Figure 1. Guangxi Province, China

Phase 2 (ongoing):
Beginning in May 2014, offspring neurodevelopment of 12-month old babies is being assessed using the Bayley Scale of Infant Development (BSID)-II (Figure 2).

Laboratory analyses (completed):

1. Maternal hair (trimester 3) total mercury and methylmercury concentrations
2. Fish tissue total mercury concentrations and rice methylmercury levels

3. Maternal serum polyunsaturated fatty acids (PUFAs)

3. RESULTS & DISCUSSION

- Hair total mercury levels averaged 0.48 (µg/g) [geometric mean = 0.41 (µg/g)] (Table 1), which was similar or lower compared to other U.S. cohorts, where fish ingestion was the primary exposure pathway (mean: 0.29-0.55 µg/g, from Oken et al., 2005; Stewart et al., 2003; Xue et al., 2007). Hair methylmercury and total mercury concentrations were highly correlated (r-squared = 0.84, p<0.0001) (Figure 3a).
- Among mothers, 87% ingested rice at least one time per day, while a subset (58%) ingested fish at least one time per month. For mothers who ingested rice daily, there were no significant differences in hair methylmercury levels between those who ingested fish 0 times per month (n=140), 1- 3 times per month (n=91), 4-24 times per month (n=90), and at least 30 times per month (n=8) (ANOVA, p=0.16) (Figure 3b).

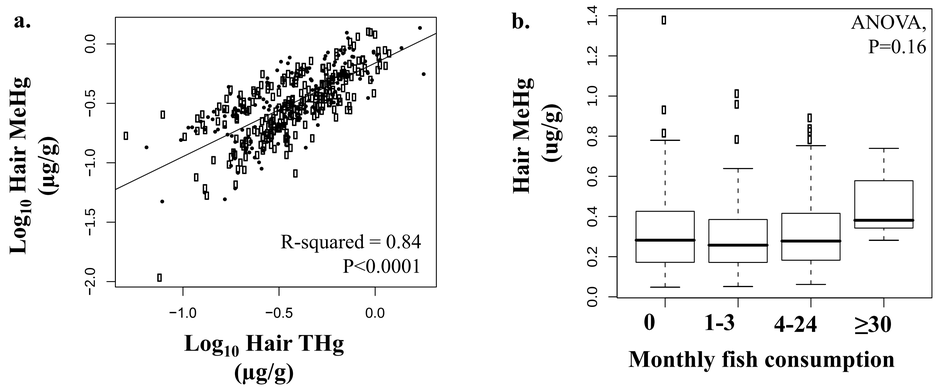

Figure 3. a) Log hair methylmercury (MeHg) versus log total mercury (THg) (r=squared = 0.84, p<0.0001). Filled circles are for mothers who eat fish at least one time per month, and open circles are for mothers who never eat fish. The disconnected observation at the bottom left side of the graph is for one mother who does not eat rice or fish, b) For mothers who ingested rice daily (n=329), comparison between the monthly fish consumption rate (ANOVA, p=0.16).

- Anthropometric measures included offspring birth length, weight and head circumference. In models adjusted for monthly fish consumption (coded 0 or 1), prenatal methylmercury exposure was inversely correlated with all parameters, but only significantly correlated with birth weight (p<0.01) (Figure 4). In Figure 4, the trend was more inverse for mothers who did not consume fish, but differences were not significant (p=0.14).

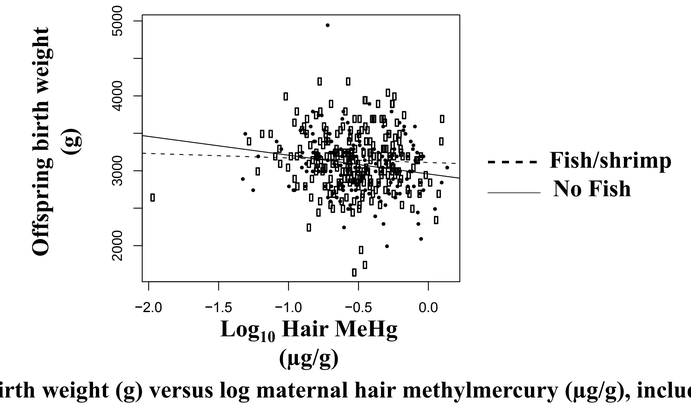

Figure 4. Offspring birth weight (g) versus log maternal hair methylmercury (µg/g), including regression trends for mothers who ingested fish at least one time per month (dotted line) and mothers who did not ingest fish (solid line) (r-squared = 0.025, p<0.01). The categorical variable for fish consumption did not contribute information to the regression model (p=0.14).

Table 1. Summary statistics for parameters, including maternal pre-pregnancy body mass index (BMI), concentrations of total mercury (THg) and methylmercury (MeHg) in maternal hair, rice and fish tissue, and long-chain polyunsaturated fatty acids including DHA (omega-3 fatty acid) (mg/mL) and the ratio between the sum of omega-6 and omega-3 fatty acids (unitless). The cohort sample size (N) is 400 mothers. In the left column sample sizes are <400 due to missing data, and in the right column rice MeHg analyses are not completed.

Parameters	N	Mean (Range)	Median	Parameters	N	Mean (Range)	Median
Maternal age (years)	375	28 (17-45)	27	Hair THg (µg/g)	400	0.48 (0.077-1.7)	0.40
Reported pre-pregnancy BMI (kg/m^2)	386	21 (15-39)	20	Hair MeHg (µg/g)	400	0.32 (0.010-1.4)	0.28
Pregnancy weight gain (kg)	392	12 (-20-40)	11	Hair %MeHg (of THg)	400	67 (14-110)	67
Male offspring	391	51%		Rice MeHg (ng/g)	203	2.8 (0.32-13)	2.2
Primipara	383	51%		Fish THg (ng/g)	13	31 (1.5-98)	23
Mother finished high school	389	17%		Serum DHA	399	0.093 (0.039-0.33)	0.088
2nd-hand smoke exposure	384	57%		Serum omega-6/omega-3	399	12 (3.5-25)	12

4. CONCLUSIONS

- Results indicated daily rice ingestion was an important methylmercury exposure pathway for most mothers, while fish/shrimp ingestion also contributed for an subset. Thus we will be able to address the main goal of the study; i.e., to determine the relationship between prenatal methylmercury exposure and offspring development in the absence of (or low levels of) fatty acids, which confound other studies but not likely to confound our study.
- Prenatal methylmercury exposure was comparable to other U.S. cohorts for pregnant wormen indicating these results will be applicable to the U.S., while providing information on prenatal methylmercury exposure to communities that depend on rice as a staple food.

5. ACKNOWLEDGEMENTS

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