

Effects of Prenatal Exposure to Mercury on Cognitive and Psychomotor Function in One-Year-Old Infants: Epidemiologic Cohort Study in Poland

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PURPOSE: The aim of the study is to assess the cognitive and psychomotor status of 1-year-old infants whose mothers were exposed to low, but varying, amounts of mercury during pregnancy.

METHODS: Mercury levels in cord and maternal blood at delivery were used to assess prenatal environmental exposure to mercury. Bayley Scales of Infant Development were used to assess neurobehavioral health outcomes. The cohort consisted of 233 infants who were born at 33 to 42 weeks of gestation between January 2001 and March 2003 to mothers attending ambulatory prenatal clinics in the first and second trimesters of pregnancy. Enrollment included only nonsmoking women with singleton pregnancies between the ages of 18 and 35 years who were free from chronic diseases.

RESULTS: The geometric mean (GM) for maternal blood mercury level for the group of infants with normal neurocognitive performance was lower (GM = 0.52 µg/L; 95% confidence interval [CI], 0.46–0.58) than that observed in the group with delayed performance (GM = 0.75 µg/L; 95% CI, 0.59–0.94), and this difference was significant ($p = 0.010$). The GM of cord blood mercury level in the normal group also was lower (GM = 0.85 µg/L; 95% CI, 0.78–0.93) than that observed in the group with delayed performance (GM = 1.05 µg/L; 95% CI, 0.87–1.27), and this difference was of borderline significance ($p = 0.070$). The relative risk (RR) for delayed performance increased more than threefold (RR = 3.58; 95% CI, 1.40–9.14) if cord blood mercury level was greater than 0.80 µg/L. Risk for delayed performance in the group of infants with greater maternal mercury levels (>0.50 µg/L) also was significantly greater (RR = 2.82; 95% CI, 1.17–6.79) compared with children whose mothers had mercury levels less than 0.50 µg/L.

CONCLUSIONS: The results may be of public health importance because delayed psychomotor or mental performance in infants is assumed to be an indicator of later neurocognitive development in children, which may persist into adult life.

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INTRODUCTION

Mercury is present in the environment in three different forms: organic, metallic, and inorganic. Chemical industry and coal-burning power plants are the major source of metallic and inorganic mercury, which, after being emitted into the air, enter water during precipitation and are converted to methylmercury by microorganisms (1–5). Methylmercury exposure is usually the result of consumption of contaminated fish foods (6, 7). Other sources of mercury exposure may be ethylmercury (thimerosal, a preservative used in some pediatric vaccines [8, 9]), mercury vapor exposure (from accidents or occupations), inorganic mercury (present in mercury-based skin creams and infant teething powders), and metallic mercury from dental amalgams (9–13). Mercury exposure also can occur from latex paints (14).

Mercury vapor and mercury compounds are absorbed easily by inhalation, digestion, and skin contact. Absorbed

Selected Abbreviations and Acronyms

BSID = Bayley Scales of Infant Development
GM = geometric mean
CI = confidence interval
RR = relative risk
CDC = Centers for Disease Control and Prevention
PDI = Psychomotor Development Index

mercury compounds rapidly bind to erythrocytes and are carried throughout the body, eventually secreted slowly in urine, feces, saliva, sweat, and breast milk. Both metallic mercury vapor and methylmercury are lipophilic and pass through the blood–brain barrier in adults and children, which may result in deposition in the central nervous system (15–23). High levels of exposure may lead to a loss of neurons in the brain lobes and such developmental effects as hyperactive reflexes, deafness, blindness, cerebral palsy, mental retardation, and general paralysis (24–30). Mercury compounds also can pass through the placenta, placing the developing fetus at potential risk (31–35).

The neurodevelopmental effect of prenatal exposure to mercury compounds in humans was shown first after two episodes of severe environmental mercury contamination. One episode occurred in Iraq, and the other, in Japan (24–28). Although recent data show that extremely high mercury exposure seldom occurs now, moderate exposure may occur not only in occupational, but also in community and domestic, settings. Because fetuses and infants are very susceptible to neurotoxic effects of mercury and its compounds, prior studies have assessed subclinical effects in children whose mothers' diets include large amounts of fish or marine mammals containing methylmercury and who have blood mercury levels greater than those commonly seen.

Although adverse health effects caused by mercury exposure have been shown clearly in poisoning incidents, implications of lower-level exposures have been controversial. Studies performed on health effects of lower exposure to organic mercury from fish or whale meat consumption produced conflicting results. A cohort of children in the Faeroe Islands was followed up until 7 years of age to document mercury levels and neurobehavioral effects of methylmercury exposure from maternal consumption of pilot whale meat (36). Neuropsychologic tests found pronounced dysfunction in the domains of language, attention, and memory at exposure levels less than what is considered safe. Conversely, a study of mother–child pairs from the ocean-fish-consuming population of the Seychelles Islands found no adverse developmental outcomes associated with prenatal or postnatal methylmercury exposure (29, 37, 38). The divergent data from these studies may result from the different biomarkers of exposure (maternal hair in the

Seychelles Islands versus cord blood in the Faeroe Islands) and different health end points used, and this may have some bearing on the statistical results.

The purpose of the present study is to assess cognitive and psychomotor status of 1-year-old infants whose mothers were exposed to low, but varying, amounts of mercury during pregnancy. Whole-blood mercury levels in cord and maternal blood at delivery measured prenatal environmental exposure to mercury, and the Bayley Scales of Infant Development (BSID) were used to assess neurobehavioral health outcomes in 1-year-olds (39).

METHODS**Study Subjects**

The cohort consisted of 233 infants who were born at 33 to 42 weeks of gestation between January 2001 and March 2003 to mothers participating in an ongoing prospective cohort study. Most of the infants (91%) were born after 38 weeks of gestation. The design of this cohort prospective study and population selection were described previously (40). Women who were residents of Krakow, one of the major cities in Poland, and attended ambulatory prenatal clinics in the first and second trimesters of pregnancy were eligible for the study. Enrollment included only nonsmoking women with singleton pregnancies between the ages of 18 and 35 years and who were free from such chronic diseases as diabetes and hypertension. On enrollment, a detailed questionnaire was administered to each subject to elicit demographic data, medical and reproductive history, date of last menstrual period, occupational exposures, and smoking practices of others present in the home. Women living with a smoker in the household or who were exposed to passive smoking in the occupational settings were treated as Environmental Tobacco Smoke (ETS) positive.

Assessment of usual dietary habits before pregnancy was performed at enrollment by means of a food frequency questionnaire, and evaluation of nutrition during pregnancy was performed by using 24-hour recall of diet in the second trimester of pregnancy. An interviewer-administered food frequency questionnaire combined with an assessment of the quantity of foods eaten assessed the usual dietary pattern for 148 beverage and food items. For each food or beverage item, a commonly used unit or portion size was specified, and participants were asked how often, on average, they consumed that amount of each food during 1 year before pregnancy. A computer program was used to calculate the nutrient content of the specified portion, using composition values from the Polish Institute of Nutrition (41, 42).

Maternal fish intake during pregnancy (in the first two trimesters of pregnancy, third trimester, and last 2 weeks) was assessed by means of a short questionnaire completed

by interviewers during the gestation period. Information on the frequency of consumption of smoked, fried, roasted, and grilled fish servings was collected. To calculate the amount of fish intake per week, we assumed that each fish meal averaged 150 g.

Blood Sample Collection and Analysis

A maternal blood sample (30 to 35 mL) at delivery was drawn into an EDTA-treated vacutainer tube. Approximately the same amount of venous blood was drawn from the clamped umbilical cord and put into another vacutainer tube. The tube then was inverted several times to mix the EDTA and blood to prevent coagulation. Blood samples for mercury and lead analysis were refrigerated without processing. Subsequently, blood samples were shipped to the Centers for Disease Control and Prevention (CDC) for chemical analysis.

In the initial phase of the study blood lead level was measured at the CDC by means of Zeeman graphite furnace atomic absorption spectrometry, using a phosphate/Triton X-100/nitric acid matrix modifier. The CDC method, using cold vapor atomic spectrometry (after chemical reduction of mercury compounds), measured total mercury (all three forms) in whole blood. In the later phase of the study whole-blood mercury and lead concentrations were determined by using inductively coupled plasma mass spectrometry. This multielement analytic technique is based on quadruple inductively coupled plasma-mass spectrometry technology. Extensive comparison studies were conducted to ensure that there was no analytical bias introduced with the new analytical methodology and accuracy and precision were both improved with the new method (43).

Neurodevelopment Testing

We used the BSID second edition (BSID-II), a well-recognized test that assesses the current developmental functioning of infants and children (39). The BSID-II consists of three scales: the Mental Scale, Motor Scale, and Behavior Rating Scale. In this study, only the first two scales were administered, which are complementary in the evaluation of the child. The Motor Scale assesses control of gross and fine muscle groups (rolling, crawling, creeping, sitting, standing, walking, running, and jumping). The Mental Scale includes items that assess memory, habituation, problem solving, early number concepts, generalization, classification, vocalization, language, and social skills. Test scores are adjusted to the age of the child to obtain the Psychomotor Development Index (PDI) and the Mental Development Index.

The BSID-II was administered to 1-year-old infants, most within 4 weeks of the target age, at the Department of Epidemiology and Preventive Medicine by trained examiners

who were unaware of the child's exposure. Test results are in one of four categories: i) accelerated performance (score ≥ 115), ii) within normal limits (score, 85 to 114), iii) mildly delayed performance (score, 70 to 84), and iv) significantly delayed (score ≤ 69). Because there were small numbers of cases with delayed motor/mental performance, to increase the power of statistical analysis, children who scored better (the first two categories) on the Motor and Mental Scales were combined into one group (normal performance), whereas children who scored low (the last two categories) on the Motor or Mental Scale were combined into another group (delayed performance).

Statistical Methods

Chi-square statistics and analysis of variance tested differences between groups with low and normal performance. Spearman rank correlation was used in the analysis of association between mercury levels in maternal or cord blood. The effect of mercury exposure in terms of cognitive and psychomotor deficits of babies under study also was assessed in multiple logistic regression models (44). In logistic models, the predictor variable (blood mercury level) was dichotomized by median values established for the group of infants with normal performance. Covariates included gender of child, gestational age, maternal age, and maternal education. In addition, the attributable fraction in the exposed group and the general population for the low-score babies (BSID II 3 + 4) at greater mercury exposure during pregnancy was calculated (45). All statistical analyses were performed using NCSS 2000 statistical system (Kaysville, UT) and BMDP 1990 statistical software (Los Angeles, CA).

RESULTS

Table 1 lists characteristics of the study population grouped by results of the BSID-II Motor and Mental Scales. As listed in Table 1, there were no significant differences in demographic characteristics of mothers and newborns in the perinatal period between infants scoring high and low, except that mothers of children in the group with delayed performance were older. The groups did not differ in respect to breast-feeding practices, ETS exposure, or lead levels measured in both maternal and cord blood. There also was no significant discrepancy between groups in dietary habits in the prepregnancy period and during pregnancy (Table 2).

The geometric mean (GM) of blood mercury levels measured in pregnant women at delivery was 0.55 $\mu\text{g/L}$ (95% confidence interval [CI], 0.50–0.61), with a range of 0.10 to 3.40 $\mu\text{g/L}$. In 75% of subjects, this level was less than 1 $\mu\text{g/L}$, and in 90%, it was not greater than 2 $\mu\text{g/L}$. The GM of blood mercury levels in cord blood was 0.88 $\mu\text{g/L}$ (95% CI, 0.81–0.95), with a range of 0.10 to 5.00 $\mu\text{g/L}$. Most

TABLE 1. Characteristics of the material by Bayley motor and mental performance in the infants under study

	Total (N = 233)	Bayley motor, mental performance		p for difference between groups with normal and delayed performance
		Motor (1 + 2) and mental (1 + 2) (N = 197)	Motor (3 + 4) or mental (3 + 4) (N = 36)	
Mother's age (years)				
Mean	27.906	27.650	29.306	0.0122
SD	3.659	3.715	3.013	
Education (years)				
Mean	15.511	15.391	16.167	0.12639
SD	2.798	2.886	2.171	
Sex n (%)				
Boys	114 (48.9%)	97 (49.2%)	17 (47.2%)	0.8239
Girls	119 (51.1%)	100 (50.8%)	19 (52.8%)	
Gestational age (weeks)				
Mean	39.339	39.360	39.222	0.6290
SD	1.573	1.551	1.709	
Birth weight (grams)				
Mean	3431.6	3445.5	3355.6	0.2929
SD	470.8	451.8	564.8	
Length at birth (centimeters)				
Mean	54.56	54.62	54.25	0.4452
SD	2.66	2.52	3.36	
Head circumference (centimeters)				
Mean	33.93	33.89	34.14	0.3365
SD	1.44	1.40	1.61	
Parity n (%)				
1	147 (63.1%)	120 (60.9%)	27 (75.0%)	0.1073
≥2	86 (36.9%)	77 (39.1%)	9 (25.0%)	
Breastfeeding (weeks)				
<25 n (%)	71 (30.5%)	60 (30.5)	11(30.6)	
26–38 n (%)	28 (12.0%)	23 (11.7%)	5 (13.9%)	
39–51 n (%)	39 (16.7%)	35 (17.8%)	4 (11.1%)	
52 + n (%)	95 (40.8%)	79 (40.1%)	16 (44.4)	0.764
Psychomotor Development Index				
Mean	97.0	99.6	83.0	<0.0000
SD	11.7	10.1	9.4	
Mental Development Index				
Mean	101.1	102.6	92.6	<0.0000
SD	9.9	8.7	11.6	
Maternal blood mercury (µg/L)				
Geometric mean	0.55	0.52	0.75	0.0101
95% Confidence interval	0.50–0.61	0.46–0.58	0.59–0.94	
Median	0.600	0.500	0.700	
Missing data	2	1	1	
Cord blood mercury (µg/L)				
Geometric mean	0.88	0.85	1.05	0.0696
95% Confidence interval	0.81–0.95	0.78–0.93	0.87–1.27	
Median	0.850	0.800	1.150	
Missing data	13	9	4	
Maternal blood lead (µg/L)				
Geometric mean	1.69	1.69	1.68	0.8989
95% Confidence interval	1.61–1.77	1.61–1.78	1.45–1.94	
Median	1.700	1.700	1.700	
Missing data	2	1	1	
Cord blood lead (µg/L)				
Geometric mean	1.28	1.27	1.34	0.5624
95% Confidence interval	1.22–1.35	1.21–1.34	1.16–1.51	

Continued

TABLE 1. Continued

	Bayley motor, mental performance			<i>p</i> for difference between groups with normal and delayed performance
	Total (N = 233)	Motor (1 + 2) and mental (1 + 2) (N = 197)	Motor (3 + 4) or mental (3 + 4) (N = 36)	
Median	1.200	1.200	1.250	
Missing data	13	9	4	
ETS n (%)				
No	135 (57.9%)	113 (57.4%)	22 (61.1%)	0.6751
Yes	98 (42.1%)	84 (42.6%)	14 (38.9%)	

infants (60%) had levels less than 1 µg/L, and 90% had mercury levels less than 2 µg/L. Mercury levels in maternal and cord blood correlated significantly with each other (Spearman rank correlation = 0.62; *p* < 0.000).

There were 197 infants with normal performance on the Motor and Mental Scales (BSID II 1 + 2) and 36 infants with delayed motor or psychomotor performance (BSID II 3 + 4). PDI scores were lower in the group with delayed performance (83.0; SD, 9.4) than in the normal group (99.6; SD, 10.1), and the difference was significant at *p* < 0.000. Corresponding mean PDI scores in these two groups were 92.6 (SD, 11.6) and 102.6 (SD, 8.7), and differences between groups also were statistically significant at *p* < 0.000.

The GM of maternal blood mercury levels for the normal group was less (GM = 0.52 µg/L; 95% CI, 0.46–0.58 µg/L) than that observed in the group with delayed performance (GM = 0.75 µg/L; 95% CI, 0.59–0.94 µg/L), and this difference was significant (*p* = 0.010). Median mercury levels in the corresponding groups were 0.50 and 0.70 µg/L.

The GM of cord blood mercury level in the normal group also was lower (GM = 0.85 µg/L; 95% CI, 0.78–0.93 µg/L) than that observed in the group with delayed performance (GM = 1.05 µg/L; 95% CI, 0.87–1.27), and this difference was of borderline significance (*p* = 0.070). Median mercury levels in the corresponding groups were 0.80 and 1.15 µg/L.

To estimate the relative risk (RR) for the occurrence of behavioral deficits in children related to blood mercury levels at delivery, logistic regression models with covariates were used. In the models, risk for delayed performance was measured against mercury blood levels dichotomized by median values in maternal or cord blood observed in the group with normal performance (Table 3). Analysis showed that the RR for delayed performance increased more than threefold (RR = 3.58; 95% CI, 1.40–9.14) at a mercury level greater than the median value in cord blood (0.80 µg/L). Similar analysis performed for mercury levels in maternal blood also showed a significantly increased risk for delayed performance (RR = 2.82; 95% CI, 1.17–6.79) if mercury level in maternal blood was greater than the median value (0.50 µg/L).

Risk estimates of the delayed performance associated with mercury exposure allowed us to calculate the expected attributable fraction for the exposed groups (greater than median mercury levels in maternal and cord blood) and the population. Hence, one should expect a decrease in 64.5% of new cases in exposed infants if maternal mercury level is less than 0.5 µg/L and a 51.6% decrease in cases at the population level. The corresponding decrease in cases if cord blood mercury level does not exceed 0.80 µg/L would be in approximately the same range of magnitude, i.e., 72.0% and 58.3%.

Fish consumption (grams per week) in mothers during pregnancy was related to mercury levels in both maternal and cord blood. Table 4 lists mercury blood levels in blood samples from mothers and their newborns cross-tabulated by tertiles of fish intake (grams per week) during various pregnancy periods. In each trimester of pregnancy, we observed a significant association between fish intake and blood mercury levels in both maternal and cord blood. The preparation method of fish dishes (cooked versus fried) did not have an impact on the observed relation between fish consumption during pregnancy and maternal blood mercury level.

DISCUSSION

Results of our study show that total mean mercury concentration (GM) in blood measured in pregnant women at delivery was 0.55 µg/L (95% CI, 0.50–0.61 µg/L); in 75% of women, it was less than 1 µg/L, and in 90%, it was not greater than 2 µg/L. In cord blood, mean total blood mercury concentration was 0.88 µg/L (95% CI, 0.81–0.95); most infants (60%) had levels less than 1 µg/L, and only 10% had a mercury level greater than 2 µg/L. Because study subjects were chosen from an urban Polish population with no occupational exposure to mercury compounds, data for blood mercury levels would reflect typical exposure in urban settings. Interestingly, fish consumption (grams per week) during pregnancy was related to mercury levels in both maternal and cord blood. We observed significant positive

TABLE 2. Dietary habits assessed for 1 year before pregnancy and during pregnancy

Nutrition	Before pregnancy		During pregnancy	
	Normal performance	Delayed performance	Normal performance	Delayed performance
Calories (Kcal)				
Mean	2255.6	2379.8	2384.14	2284.60
SD	658.5	597.3	735.03	599.93
Proteins (g)				
Mean	82.0	86.2	77.51	80.02
SD	25.7	22.1	25.66	22.90
Fats (g)				
Mean	88.1	92.9	79.73	74.94
SD	31.2	27.9	35.18	26.75
Carbohydrates (g)				
Mean	247.2	260.1	364.31	347.73
SD	75.9	67.0	127.10	103.27
Retinol equivalent (µg)				
Mean	1294.5	1223.4	1573.7	2381.8 ^a
SD	684.0	460.1	1437.7	4164.2
Retinol (µg)				
Mean	833.6	784.2	648.9	1764.4 ^a
SD	641.3	405.0	1112.8	4253.7
Carotene (µg)				
Mean	3583.0	3456.3	5540.6	3698.9
SD	2261.5	1815.1	5937.5	3131.6
Vitamin E (mg)				
Mean	12.1	12.4	12.81	12.28
SD	3.36	4.3	5.86	4.56
Vitamin B ₁ (mg)				
Mean	1.32	1.34	1.44	1.47
SD	0.50	0.43	0.52	0.49
Vitamin B ₂ (mg)				
Mean	1.75	1.87	1.90	2.19
SD	0.55	0.49	0.72	1.06
Vitamin PP (mg)				
Mean	31.1	32.37	14.19	16.22
SD	9.50	7.74	5.09	7.56
Vitamin C (mg)				
Mean	143.67	147.24	229.4	229.2
SD	67.96	70.11	164.6	134.6
Calcium (mg)				
Mean	867.8	965.9	921.3	910.1
SD	309.7	288.0	479.2	431.7
Iron (mg)				
Mean	14.36	14.54	12.41	13.56
SD	4.01	3.60	4.28	6.82

^aVitamin PP- pellagra preventing factor.

correlations between fish intake by women in pregnancy and mean total mercury levels in both maternal and cord blood.

Results of our study suggest that cord and maternal blood mercury levels are associated with delayed psychomotor development of infants in the first year of life. We show that the RR for delayed performance increased more than three-fold (RR = 3.58; 95% CI, 1.40–9.14) if cord blood mercury level was greater than GM 0.80 µg/L. The RR for delayed

performance in the group of infants with greater maternal mercury levels (>0.50 µg/L) also was significantly greater (RR = 2.82; 95% CI, 1.17–6.79) compared with children who had a mercury level less than 0.50 µg/L. These results may be of public health importance because delayed psychomotor or mental performance in infants is assumed to be an indicator of later neurocognitive development in children, which may persist into adult life (46, 47).

Results of our study are consistent with many previous studies. Recent data from the National Health and Nutrition Examination Survey in 1999 to 2000 of 2314 women of childbearing age in the nationally representative United States (48) showed that the GM of total blood mercury levels was 0.34 µg/L (95% CI, 0.30–0.39), and in 1250 children aged 1 to 5 years, it was 1.02 µg/L (95% CI, 0.85–1.20 µg/L). As in our study, total blood mercury level was related to self-reported fish consumption in both children and women. Population-based estimates of blood mercury levels available from Germany (49) showed that in adults never eating fish, the GM blood mercury level was 0.30 µg/L, and in those who consumed fish more than once a week, the GM level was 0.77 µg/L. In the study performed by Stern and Burger (50) in New Jersey pregnant women, mean total blood mercury level was 0.99 µg/L (SE, 0.28 µg/L). Mean total blood mercury level in residents of the Quebec area was 1.10 µg/L (SE, 0.05 µg/L), and in persons who consumed fish from lakes, it was significantly greater (mean, 1.29 µg/L; SE, 0.09 µg/L). Tentative reference values for typical blood mercury concentrations in non-occupationally-exposed people were estimated by Brune et al. (51) based on a review of 132 data sets worldwide. In studies with fish consumption information, average mercury blood level in those who did not eat fish was 2.0 µg/L, and in those who ate more than two to four servings of fish per week, blood mercury level was 8.4 µg/L.

As in other studies, we show that the gradient of mercury concentrations “cord blood–maternal blood” was far from 1:1 (52–54). Differences could not result from laboratory bias because maternal and cord blood samples were collected, stored, and analyzed in the same manner by the same laboratory, and samples were blinded for laboratory personnel. A possible reason is that mercury binds to hemoglobin, and newborns have greater hematocrit and hemoglobin concentrations. However, other possible mechanisms have been discussed in the literature (54).

The relative narrow range of exposure in our study sample did not allow us to assess exact dose–response relationships; however, results indicate possible adverse effects at sea levels below those previously shown to increase the risk for delayed neurodevelopment of infants. If confirmed the finding that children with mercury concentrations greater than 0.80 µg/L in cord blood or greater than 0.50 µg/L in maternal blood showed a significantly

TABLE 3. Predicted AF in the exposed group and the population for the low motor or mental performance (BSID-II) related to mercury levels in cord and maternal blood

Predictor variable	Normal performance	Delayed performance	Total
Mercury in cord blood < 0.8 µg/L	85 (93.4%)	6 (6.6%)	91
Mercury in cord blood ≥ 0.8 µg/L	103 (79.8%)	26 (20.2%)	129
N	188	32	220
RR = 3.58 (95% CI, 1.40-9.14); AF(exp) = 72.0%; AF(pop) = 58.3% (95% CI, 28.6-83.3)			
Mercury in maternal blood < 0.5 µg/L	81 (92.0%)	7 (8.0%)	88
Mercury in maternal blood ≥ 0.5 µg/L	115 (80.4%)	28 (19.6%)	143
N	196	35	231
RR = 2.82; (95% CI, 1.17-6.79); AF(exp) = 64.5%; AF(pop) = 51.6% (95% CI, 22.1-80.0)			

AF, attributable fraction; AF(exp), AF for exposed group; AF(pop), AF for the general population; BSID-II, Bayley Scales of Infant Development II; RR, relative risk; CI, confidence interval.

greater probability of delayed psychomotor or mental performance, would suggest the need to re-evaluate current health-based standards. The different cutoff values, i.e., 0.8 µg/L for mercury cord blood and 0.5 µg/L for maternal blood, may be explained by the lower mercury levels in maternal blood.

Our study has potential limitations, but also strong points. First, the study population may be not be representative of the female urban population in the country because enrollment covered only pregnant nonsmoking women with singleton pregnancies between the ages of 18 and 35 years who were free from such chronic diseases as diabetes and hypertension. However, these inclusion criteria helped us eliminate from the study infants who were at greater risk for neurocognitive disorders because of maternal chronic diseases or active smoking. In our understanding, the strength of the study lies in that we considered

a set of important confounders potentially affecting child development, such as maternal age and education, lead level exposure, and nutrition habits before and during pregnancy, in the analysis of neurodevelopmental outcomes. The groups of infants under comparison did not significantly differ in respect to any of these variables.

In summary, we show that mercury exposure in a European country with relatively low seafood consumption also clearly is related to fish intake. This study is the first report on developmental outcome in infants associated with mercury exposure during pregnancy performed in central and eastern European countries. Awareness of this exposure and its health hazards is uncommon in these countries, not only in the population at large, but also among pediatricians and public health officers. However, the results require confirmation in additional studies and evaluation of health effects during a longer follow-up period.

TABLE 4. Mean and median mercury blood levels and amount of fish consumption during various pregnancy periods

Fish consumption during pregnancy periods (g/wk)	Mercury in cord blood (µg/L) Mean (SD)	Mercury in maternal blood (µg/L) Mean (SD)
Trimester I + II		
Tertile 1 (0-70 g/wk) (N ₁ = 78, N ₂ = 80)	0.927 (0.638)	0.589 (0.479)
Tertile 2 (71-150 g/wk) (N ₁ = 79, N ₂ = 85)	1.010 (0.547)	0.792 (0.651)
Tertile 3 (> 150 g/wk) (N ₁ = 63, N ₂ = 66)	1.267 (0.932)	0.812 (0.568)
Analysis of variance	F = 4.26; df, 2, 217; p = 0.015	F = 3.61; df, 2, 228; p = 0.029
Trimester III		
Tertile 1 (0-55 g/wk) (N ₁ = 72, N ₂ = 78)	0.839 (0.496)	0.569 (0.417)
Tertile 2 (56-160 g/wk) (N ₁ = 79, N ₂ = 82)	1.062 (0.695)	0.738 (0.647)
Tertile 3 (> 160 g/wk) (N ₁ = 69, N ₂ = 71)	1.280 (0.866)	0.889 (0.609)
Analysis of variance	F = 7.25; df, 2, 217; p = 0.001	F = 5.93; df, 2, 228; p = 0.003
Total		
Tertile 1 (0-165 g/wk) (N ₁ = 75, N ₂ = 79)	0.893 (0.662)	0.565 (0.470)
Tertile 2 (166-340 g/wk) (N ₁ = 71, N ₂ = 75)	1.014 (0.560)	0.761 (0.618)
Tertile 3 (> 340 g/wk) (N ₁ = 72, N ₂ = 77)	1.274 (0.858)	0.861 (0.606)
Analysis of variance	F = 5.67; df, 2, 217; p = 0.004	F = 5.52; df, 2, 228; p = 0.005

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