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Mercury in Women Exposed to Methylmercury through Fish Consumption, and in Their Newborn Babies and Breast Milk

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The presence of methylmercury in fish is a major environmental problem (cf WHO 1976). During the major epidemics of methylmercury poisoning through sea food in Minamata in Japan (cf. Fujita and Takabatake 1977), and through dressed seed in Iraq (Bakir et al 1973; Amin-Zaki et al 1976; Marsh et al 1980), there was a high prevalence of infants, who developed cerebral palsy.

This was generally assumed to be due to intrauterine methylmercury poisoning, as it is well known, that methylmercury is transferred through the placenta into the fetus. There is also a possibility that exposure occurred through breast milk, as high levels of mercury in breast milk have been reported in mothers from Minamata (Fujita and Takabatake 1977), and Iraq (Bakir et al 1973; Amin-Zaki et al 1976).

Information on the relationship between methylmercury exposure, mercury levels in blood of mothers and their babies, and levels in breast milk are reported here.

MATERIAL AND METHODS

Blood samples were obtained from 10 women and their newborn babies, breast milk from 15 women. Their age ranged 18-38 years. Twelve mothers had their first child, three their second.

One woman was a lacto-vegetarian, and thus consumed no fish at all. In the others, the *fish consumption* was assessed, as described earlier (Jonsson et al 1972). Two women had only fish from off-shore parts of the ocean (mercury level 0.05 mg/kg, or less; 1-2 meals/week). Twelve women were fishermen's wives. They had fish from coastal areas of the Baltic, the Gulf of Bothnia, or Lake Mälar. The level in fish from those areas range 0.3-0.8 mg/kg, and consists almost entirely of methylmercury (WHO 1976). A rough estimate of the *methylmercury intake* through fish ranged an average of 0-0.9 µg Hg/kg body weight/day, during the last year. However, in most subjects, there was a considerable seasonal variation. No mother had any occupational exposure to mercury.

Blood samples were obtained (in nine cases at delivery, in one case one week later), in the *women* by venipuncture into acid-washed tubes containing heparin, within a few hours before delivery, in the *newborn infants* by sampling of cord blood at delivery. In three women and in two infants, additional samples of blood were obtained up to 255 days after delivery.

The samples were sent to the laboratory by mail. Blood cells and plasma were separated, as described earlier (Skerfving 1974). Hemoglobin levels in plasma were determined. The levels were low; in four samples with visually obvious hemolysis, they ranged 1-3 g/l, the others were lower.

Milk samples were, in 13 cases, obtained within a week (mostly 2-3 days) after delivery (colostrum was avoided). In two cases, the first samples were obtained up to 127 days after delivery. In three women, additional samples were obtained. Sampling was made after the infant had been fed in the morning, into acid-washed bottles, which then were shipped by mail to the laboratory, and kept frozen at -20 °C until analysis.

Total mercury was analysed in duplicate by neutron activation analysis (Sjöstrand 1964). The detection limit was 0.5 ng/g. The precision, at repeated analysis of a plasma sample containing 2 ng/g, was 35%, and of a blood cell sample containing 120 ng/g, 11%.

Milk was analysed for *methylmercury* by gas chromatography, according to Westöö (1973). The detction limit of the method was about 0.1 ng Hg/g. In some of the chromatograms, there were interfering peaks.

RESULTS AND DISCUSSION

The *blood cell* mercury levels in *mothers* ranged from 2 ng/g in the vegetarian subject, who never had fish, over 6 and 10 ng/g in the two subjects, who only had commercial fish, to 12-72 ng/g in subjects who had methylmercury-contaminated fish from coastal waters and lakes. The levels in plasma were lower; the ratios between levels in blood cells and plasma were 1.7, 4.9 and 6.1, and 2.4-12, respectively, in the corresponding subjects.

The levels of mercury in blood cells are in accordance with those found among Swedes with different intakes of fish (Skerfving 1974). Taking into consideration the relationship between levels in blood and hair (WHO 1976), the present levels in the women are much higher than those reported in population studies of pregnant women in Sweden (Ohlander et al 1985). The reason is probably, that the majority of the present mothers were selected, not randomly, but because they had

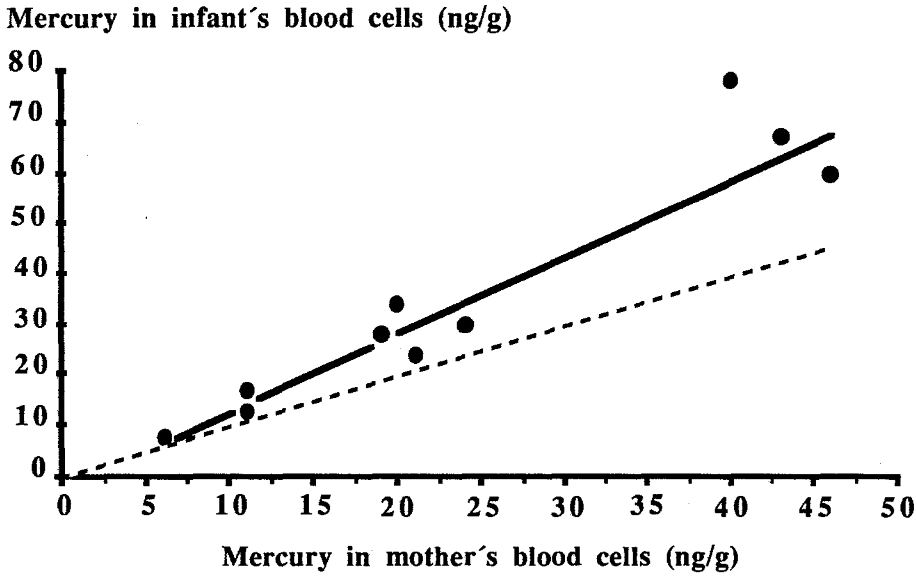

Figure 1. Relationship between total mercury in blood cells obtained at delivery from 10 pregnant women and their newborn infants (cord blood). A (broken) line of identity is shown, as well as a regression line (full; Y=1.6X-3).

a particularly high intake of contaminated fish. Also, the samples were obtained several years earlier; the exposure may have decreased later.

The levels in the mothers are well below those supposed to cause poisoning in adults (WHO 1976). However, the highest levels are comparable to those assumed to constitute a risk of effects on the central nervous system in infants (Marsh et al 1980; Kjellström et al 1986). The official recommendation in Sweden to pregnant women not to eat methylmercury contaminated fish (Ohlander et al 1985) is thus well-founded.

There was a close correlation ($r=0.96$; $p<0.001$; Figure 1) between blood cell levels in 10 mothers (mean 24; range 6-46 ng/g) and in their newborn babies (36; 6-45 ng/g). The babies had higher ($p<0.001$) levels than their mothers, in average by 47%; this fraction did not display any obvious dependence upon level. Higher levels in infants were also found, when mercury concentrations were calculated on basis of hemoglobin content.

The finding of higher levels in blood cells in infants, as compared to their mothers, is in accordance with earlier observations (Tejning 1970; Suzuki et al 1971; Bakir et al 1973). The reason for the mother/infant difference is not known. In adults, the mercury in blood cells is present as methylmercury (Bakir et al 1973); it is probable (but not shown), that this is the case also in babies. The mother/infant

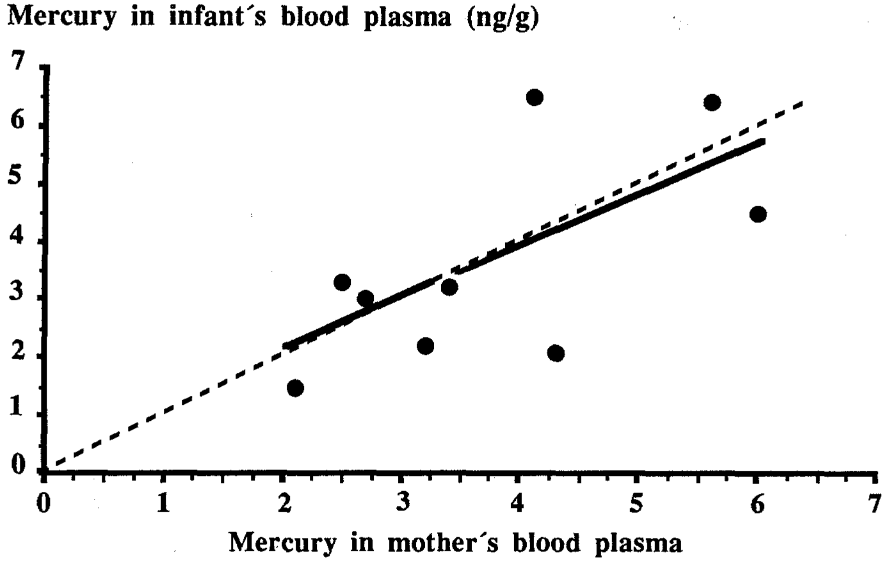

Figure 2. Relationship between total mercury levels in plasma obtained at delivery from nine pregnant women and their newborn infants (cord blood). A (broken) line of identity is shown, as well as a regression line (full; Y=0.84X+0.41).

difference might be due to variations in binding of the mercury in the blood cells. It might be speculated, that the difference in concentrations may not be confined to the red cells, but may be present also in the central nervous system (CNS), and that this may explain why the fetus is more susceptible than the pregnant woman (Marsh et al 1980; Clarkson et al 1985; Kjellström et al 1986).

Nine mothers had mercury levels in *plasma* (mean 3.8; range 2.1-6.0 ng/g; Figure 2), which did not differ statistically significantly from their babies (3.6; 1.5-6.5 ng/g). There was a correlation ($r=0.66$, $p<0.05$) between mercury levels in plasma in the mothers and newborn infants. The ratio between levels in blood cells and plasma ranged 4.9-15 in the babies.

The *total mercury* concentration in *milk* averaged 3.1(range 0.2-6.3) ng/g in 15 mothers (Figure 3). There were significant correlations between total mercury levels in blood cells ($r=0.67$, $p<0.01$) and plasma ($r=0.74$, $p<0.01$ on the one hand, and in milk on the other. The correlation was not better if mercury levels in milk were expressed on basis of nitrogen content. The levels in plasma were similar to those in milk; there was no statistically significant difference. Further, there was no obvious variation, in this sense, between samples obtained during the first week after delivery, and those five obtained later.

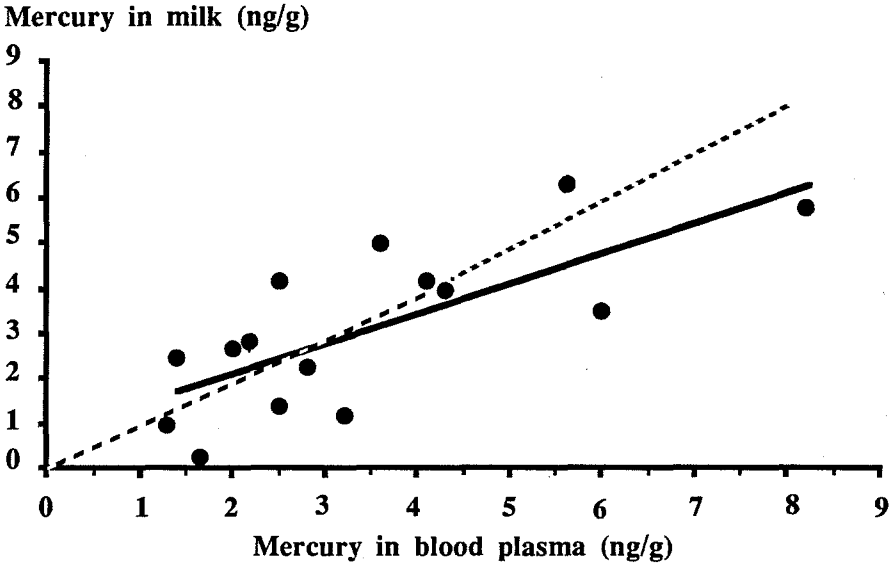

Figure 3. Relationship between total mercury levels in plasma and breast milk in 15 women. A (broken) line of identity is shown, as well as a regression line (full; Y=0.67X+0.83).

The levels of total mercury found in this study are in general agreement with data reported earlier on levels in cow and human (subjects without particular methylmercury exposure) milk from Sweden (Westöö 1973), similar to those found in Eskimos in Alaska (Galster 1976) and in Japan (Fujita and Takabatake 1977), but much lower than those in subjects from the Minamata region (Fujita and Takabatake 1977) and Iraqis, who had consumed methylmercury-dressed seed (Bakir et al 1973; Amin-Zaki et al 1976). The differences reflect variations in methylmercury exposure.

The mean *methylmercury* level in milk was 0.6 (range 0.2-1.2) ng/g. There was a significant correlation ($r=0.84$, $p<0.01$) between total mercury and methylmercury levels in milk (Figure 4, next side). The methylmercury fraction averaged 20% (range 7-33) of the total mercury. There was no obvious systematic deviation of this fraction within the range studied.

Thus, most of the mercury in breast milk was probably inorganic. The methylmercury fraction recorded here is lower than in the Iraqi mothers (Bakir et al 1973), who had, however, a much higher exposure. Still, the present low fraction might seem surprising, because even the exposure in the present mothers was mainly to methylmercury (Jonsson et al 1972), and since this compound is assumed to be rather stable in the body (WHO 1976). However, the mercury in milk may reflect the plasma mercury pattern; the plasma contains a relatively large fraction of inorganic mercury (Nordberg and Skerfving 1972), and is less affected by methylmer-

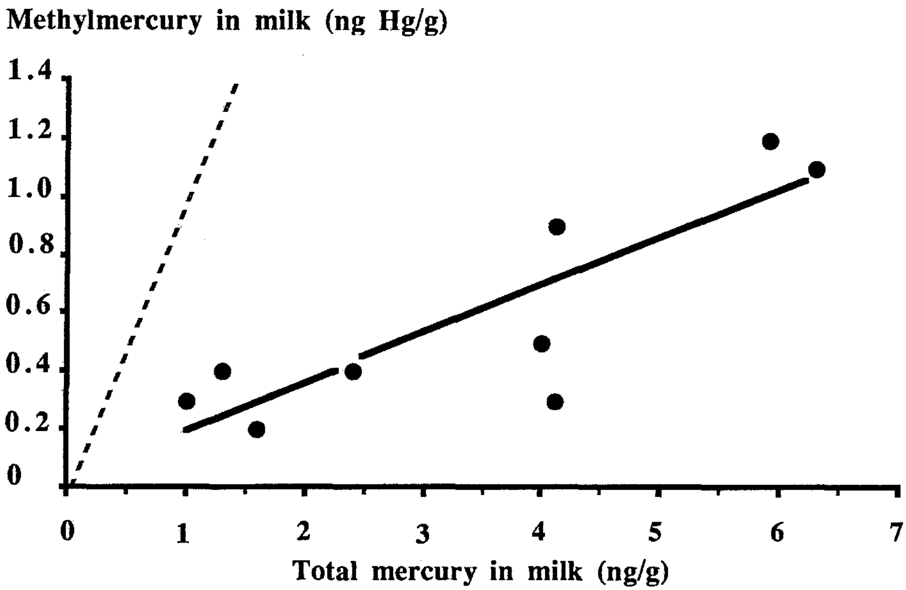

Figure 4. Relationship between methylmercury and total mercury levels in breast milk in nine women. A (broken) line of identity is shown, as well as a regression line (full; Y=0.16X+0.02).

cury exposure than e.g. the blood cells (Skerfving 1974). Indeed, our levels of mercury in milk were similar to those in plasma. The relationship between levels in milk and plasma is compatible with that reported from Iraq (Bakir et al 1973).

Of ingested inorganic mercury, only a small fraction is absorbed from the gastrointestinal tract (at least in adults; Nordberg and Skerfving 1972), while methylmercury is absorbed almost completely (WHO 1976). Thus, the *methylmercury* content in the milk is of greatest interest. For this compound, an intake of 0.3 μg Hg/kg body weight/day has been proposed as a highest tolerable in adults (WHO 1976). This corresponds to a total mercury level of about 5 ng/g in plasma and a methylmercury level of about 1 ng Hg/g in milk. The infant's intake of breast milk may be as high as 0.15 l/kg body weight/day, which would then correspond to a methylmercury exposure of about 0.15 μg Hg/kg body weight/day, which is thus considerably lower than in the mother. In spite of this, the infant may be more susceptible. If *total mercury* intake is considered, the infant is probably more exosed than its mother.

In three families, repeated samples of blood from mothers and/or blood from infants and/or milk was obtained. There was no obvious time trend of mercury levels in samples of *milk* from two women (total mercury 0.6-1.6, methylmercury 0.6-1.1 ng Hg/g; and total mercury 5.3-6.3, methylmercury 0.2-0.4 ng Hg/g, respectively). The total mercury levels in *blood cells* decreased, both in one infant, who received breast milk for 4 months (infant 60 to 34, mother 45 to 38 ng/g) and in one who had mixed feeding for 3 months (infant 78 to 26, mother 40 to 24 ng/g).

The relatively low methylmercury exposure may be the explanation of the decreasing blood mercury levels in the two babies. Alternatively, growth and/or changes in mercury binding in blood (fetal type of hemoglobin is exchanged into adult type) may be the cause. The decrease in the mothers may be due to a decrease in exposure, or to an increase in elimination of mercury, because of the excretion in milk (Greenwood et al 1978).

However, considering the possibility, that the excretion of methylmercury in newborns is slower than in adults (cf. Clarkson et al 1985), and that it is probable, that the CNS of the infant is more susceptible than in adults (Marsh et al 1980; Clarkson et al 1985; Kjellström et al 1986), the recommended restriction of intake of methylmercury-contaminated fish in pregnant Swedish women (Ohlander et al 1985), should be expanded to lactating ones.

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