Written testimony by

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My name is Philippe Grandjean. I am an MD, PhD, and I work as an Adjunct Professor of Environmental Health at Harvard School of Public Health in Boston. I am also a Professor and Chair of Environmental Medicine at the University of Southern Denmark. I apologize for not being able to be present today due to commitments in Europe and my field studies in the Faroe Islands. I am grateful to you for allowing me to present a short summary of the current status of our studies of adverse effects of methylmercury in regard to human health.

I started studying the effects of mercury on human health almost 20 years ago. Together with Dr. Pal Weihe, I collected information on births in the Faroe Islands, a fishing community located in the North Atlantic between Norway and Iceland. In over 1,000 children, we determined the prenatal exposure to methylmercury by analyzing the cord blood for mercury. The mercury originated from the traditional Faroese diet, which includes pilot whale meat in addition to frequent meals of fish and shellfish. The pilot whale is a toothed whale that eats fish and squid, and the mercury concentration in the meat corresponds to the levels in swordfish and shark, or higher.

When we examined the children at age 7 years with sophisticated neurobehavioral methods, we found that increased prenatal mercury exposure was associated with deficits in several brain functions, including attention, language, verbal memory, spatial function and motor speed. These associations could not be explained away by a multitude of other factors that we also recorded. In fact, the Faroese population is relatively uniform, and whale meat is freely shared when available, so that one would not expect that socioeconomic or other factors would play any great role.

In 2000, the National Research Council released its report on the Toxicology of Methylmercury. This report identified our work as critical evidence in regard to identifying an exposure limit for methylmercury. The NRC committee used the so-called benchmark dose for these calculations and agreed with the U.S.EPA that an exposure limit of 0.1 micrograms per kilogram of body weight per day was justified.

Since then, our research has made substantial progress, and I would like to share some of these achievements with you.

One insight comes from efforts in statistical theory by my colleague, Dr. Esben Budtz-Jorgensen, a Danish statistician who now works as a postdoc at Harvard. Esben first calculated the degree of imprecision of the exposure assessments – that is, in this case, how well the cord-blood mercury concentrations reflected the ‘true’ exposure. Imprecise exposure assessments result in an underestimation of the true effect of an exposure, in this case methylmercury. We had anticipated that our mercury measurements would not be a precise measure of the dose that the fetus (especially the fetal brain) had received. But Esben documented that the measurement error was much greater than we had thought. In addition, the mercury concentration in the mother’s hair was a poor measure of the ‘true’ exposure to the fetus.

Such imprecision of course also affects the calculations of benchmark doses. Esben has now calculated the influence on the results that the NRC used in their report. In short, the benchmark dose has been overestimated by a factor of 2. Accordingly, if we were to calculate an exposure limit today by the same procedure as the one used by the NRC, now using the adjusted benchmark dose, then the exposure limit would be only one-half of the limit used by the U.S.EPA.

Another issue of importance is how you convert mercury concentrations in hair to concentrations in blood and vice versa. The calculation originally presented by the NRC was based on cord blood and needs to be adjusted to the concentration in adult whole blood. The EPA now estimates the annual number of births in the US that exceed the EPA exposure limit to be 630,000. However, the number would have been even larger, had the EPA used the adjusted exposure limit.

Current risk assessments have been based on the assumption that the fetal brain is the most sensitive organ. Brain development also continues after birth, but we have been uncertain how long an increased susceptibility to mercury might last. Accordingly, some states have chosen to warn against mercury exposure from fish only with regard to pregnant women, while others have included children up to various age levels. Our new results, just published in The Journal of Pediatrics in the February issue shed new light on the vulnerability of the brain.

We had recently examined the Faroese children again at age 14 years, and the tests carried out included brainstem auditory evoked potentials. In this test, the child was hearing a sound from a headset, and we then recorded the resulting electrical activity in the brain using surface electrodes placed on the skull. Using standard clinical procedures, we measured the transmission of the electrical signal from the acoustic nerve through a series of ‘relay’ stations in the brain. We found that the latency, or transmission time, of the signal from the acoustic nerve to the brainstem was significantly increased at higher prenatal exposure to mercury. This was true both at 7 years and at 14 years, suggesting that this effect of mercury on the developing brain is irreversible.

This mercury-associated delay in transmission appeared to be parallel to the effects on the child’s cognitive functions that I mentioned before. The measurement of electrical signals is regarded an objective assessment that is independent of factors, such as age and socioeconomics. It therefore represents an important, independent confirmation of the neurotoxicity of methylmercury from seafood. We are currently working on the neuropsychological test results at age 14 years to see whether they too, as we anticipate, reflect lasting mercury toxicity. So I can’t report on these results yet.

An additional finding at age 14 years was that a subsequent component of the signal transmission to the midbrain was delayed at higher current mercury exposures, but in this case it was not affected by prenatal exposure. Postnatal mercury exposure up to adolescence therefore also seems capable of damaging brain functions, although they may not be the same as those that are sensitive to mercury during fetal development. This conclusion is entirely plausible and agrees with experimental animal studies.

It is noteworthy that these children at age 14 had an average exposure that was similar to the exposure limit used by the U.S.EPA, and that 95% of them had exposures below the level which has previously been considered safe by the FDA. Yet, at these exposure levels, we saw a steady slope of increasing delays of the electrical signals, the higher the mercury exposure: The delay in the signals appeared already at mercury doses below the EPA limit.

All of these results regard cognitive effects and other changes of brain functions. The autonomic nervous system performs important, but unconscious functions, such as regulating the heart beat, the blood pressure, etc. We have now found that the mercury-associated neurological changes are also linked to decreased nervous system control of the heart function. At higher mercury exposures, the children were less capable of maintaining the normal variability of the heart rate necessary to secure proper oxygen supply to the body and to maintain an appropriate blood pressure.

This finding has wider potential relevance, because other research has suggested that mercury from fish may increase the risk of heart disease and of dying from heart disease. The most recent reports were published in The New England Journal of Medicine in November, 2002. We suspect that part of the reason for these findings is that the mercury affects the autonomic nervous system and its control of the heart function. Such effects are of course highly relevant to Americans in general. These new results therefore suggest that we should not only be concerned about mercury exposures of pregnant women and small children. The EPA report that over 10% of all births every year exceed the exposure limit should therefore also be considered in regard to the population at large.

The importance of brain functions means even a small deficit, whether measured as a decrease in IQ points or otherwise, is likely to impact on an individual’s quality-of-life, academic success and economic prospects in life. Even though the children that we examined were all basically normal, we have documented detectable deficits that appear to be permanent. I would consider such changes as adverse health effects that should be prevented. Further, even a small increase in the incidence of heart disease is important, because cardiovascular disease is the major cause of death in this country.

Freshwater fish and seafood are excellent supplies of energy and essential nutrients. If fish is not contaminated with mercury, it will help prevent heart disease. I believe that it is an important effort to support public health to prevent mercury contamination of the environment.

Thank you.