International Journal of Hygiene and Environmental Health 220 (2017) 1161–1167

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Maternal prenatal blood mercury is not adversely associated with offspring IQ at 8 years provided the mother eats fish: A British prebirth cohort study

Jean Golding[a,*], Joseph R. Hibbeln[b], Steven M. Gregory[a], Yasmin Iles-Caven[a], Alan Emond[a], Caroline M. Taylor[a]

[a] Centre for Child and Adolescent Health, School of Social & Community Medicine, University of Bristol, Oakfield House, Oakfield Grove, Bristol BS8 2BN, UK
[b] Section on Nutritional Neurosciences, National Institute on Alcohol Abuse and Alcoholism, National Institutes of Health,5625 Fishers Lane, Rm 3N-07, MSC 9410 Bethesda, MD 20892, USA

ARTICLE INFO

Article history:
Received 30 March 2017
Received in revised form 12 July 2017
Accepted 13 July 2017

Keywords:
ALSPAC
Mercury
Fetal exposure
Childhood IQ
Prenatal fish consumption

ABSTRACT

Background: Conflicting evidence concerning possible harm from mercury (Hg) in regard to offspring cognition if the woman eats fish has prompted this study to examine evidence from a British pre-birth cohort to investigate the relationship between the two.

Methods: Pregnant women (median prenatal blood mercury 1.86 μg/L) resident in the study area with delivery between April 1991 and December 1992 were followed up and verbal, performance and total intelligence quotient (IQ) of 2062 offspring were measured at age 8. Analysis treated IQ as (a) continuous and (b) the lowest 25% of the distribution. Multiple and logistic regression analyses took account of social and demographic variables. Stratification considered children of fish eaters separately.

Results: Before adjustment, mean full-scale IQ increased with increasing Hg (change with 1SD of Hg = +2.02; 95%CI +1.40,+2.64 IQ points; P < 0.0001); after adjustment effect size was reduced although still positive (+0.61;95%CI -0.06,+1.29 IQ points; P = 0.073). The adjusted positive relationship was stronger when fish-eating mothers were considered separately (+0.84:95%CI +0.13,+1.56 IQ points; P = 0.021) in comparison with the outcomes for non-fish eaters, where the adjusted relationship was negative (-2.22;95%CI -5.00,+0.56 IQ points; P = 0.117). The binary outcome showed a similar pattern with the adjusted OR for non-fish-eaters 1.79 (95%CI 1.10,2.93; P = 0.019) per SD of Hg, significantly different from that for fish consumers (0.94;95%CI:0.82,1.08)($P_{interaction}$<0.05). There were no differences between the sexes in the associations, nor did the level of the mother's blood selenium change the effect sizes.

Conclusion: The relationship between intrauterine exposure to mercury and offspring IQ appears to be benign provided the mother consumes fish.

1. Introduction

Cognition, measured as an intellectual quotient (IQ), is one of the fundamental attributes associated with educational and occupational achievements. Economists estimate that the earning power of an individual increases by 2% for each increase in a single IQ point with, at the population level, consequent increases in the annual income of nations – that of the USA is measured in hundreds of billions of dollars (Grosse et al., 2002). Consequently it is in the interest of all nations to maximize the mean IQ of their population by fostering the environmental components that improve IQ while reducing those that diminish it.

Epidemiologists and risk assessors have struggled to interpret the scientific evidence pertaining to mercury in seafood as it relates to cognition. Although there is strong evidence from major accidents involving mercury contamination demonstrating serious offspring brain damage resulting from prenatal exposure to very high levels of mercury (Harada, 1968), a number of studies have shown positive benefits to the neurocognition of the offspring if

* Corresponding author at: Centre for Child and Adolescent Health, School of Social & Community Medicine, University of Bristol, Oakfield House, Oakfield Grove, Bristol BS8 2BN, UK.

E-mail addresses: jean.golding@bristol.ac.uk (J. Golding), jhibbeln@mail.nih.gov (J.R. Hibbeln), Steven.Gregory@bristol.ac.uk (S.M. Gregory), cdylic@bristol.ac.uk (Y. Iles-Caven), alan.emond@bristol.ac.uk (A. Emond), Caroline.M.Taylor@bristol.ac.uk (C.M. Taylor).

http://dx.doi.org/10.1016/j.ijheh.2017.07.004
1438-4639/

the mother consumes fish prenatally in spite of the fact that fish contains mercury (Hibbeln et al., 2007; Oken et al., 2005; Mendez et al., 2009; Starling et al., 2015). Advice to pregnant women tends to be confusing, and their reaction appears to be dominated more by the fear of exposure to mercury than the benefits of fish.

The analyses in this paper are designed to provide further information to help address the scientific argument. We use the Avon Longitudinal Study of Parents and Children (ALSPAC) (Boyd et al., 2013), which is the largest study to date to have relevant information available. The aims of our analyses of these data are to determine whether: (a) prenatal blood mercury levels were associated with either lower mean offspring IQ or increased risk of low level IQ; (b) maternal seafood consumption or blood selenium levels offset any negative effects of maternal mercury in regard to offspring IQ, and (c) results are sex-specific.

2. Methods

2.1. The participants

The ALSPAC study aimed to enroll all pregnant women residing in Avon (a geographically defined area in South West England) with an expected delivery date between April 1991 and December 1992. The study enrolled 14,541 pregnant women, estimated as about 80% of those eligible. Its stated aims were to evaluate genetic and environmental influences on health and development (Boyd et al., 2013).

Information was collected prenatally using self-completion questionnaires sent to the mothers and their partners in their own homes and blood was collected at their first antenatal visit. The study website contains details of all the data collected subsequently that are available through a fully searchable data dictionary: http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/

2.2. The exposures

2.2.1. Trace metal exposures

Blood samples collected in acid-washed containers specifically for determination of trace metals were obtained from 4484 women by midwives as early as possible in pregnancy. The sociodemographic characteristics of the women who donated samples were mostly comparable to those of the rest of the ALSPAC study population although they were slightly more likely to be older and better educated (Taylor et al., 2013). Gestational age at sample collection had a median value of 11 weeks and mode of 10 weeks. The interquartile range (IQR) was 9–13 weeks, and 93% of the samples were collected at <18 weeks gestation. Samples were stored as whole blood in the original collection tubes for 18–19 years. Analyses were carried out in the laboratory of Dr. Robert Jones at the Centers for Disease Control and Prevention (CDC) for whole blood mercury and selenium (CDC method 3009.1; unpublished information). Further details are given elsewhere (Golding et al., 2013). The distributions were approximately normal for selenium and slightly skewed for mercury. There were 4134 women with recorded mercury levels which ranged from below the limit of detection (LOD) (0.24 μg/L) to 12.76 μg/L, with a median of 1.86 μg/L. For the three individuals below the LOD, a value of 0.7 times the LOD value was ascribed to the sample. Valid levels of selenium were available for 4287 pregnancies. The range of selenium levels was from 17.0 to 324.1 with median 108 μg/L; no samples were below the LOD.

2.2.2. Maternal diet

A questionnaire sent to the mother at 32 weeks gestation included a food frequency questionnaire comprising 103 food and drink items including two items related to fish intake: white fish and oily fish (Rogers and Emmett, 1998). The participants were given guidelines to classify the types of fish from those that were most prevalent in the UK. Thus oily fish was described as including 'salmon, mackerel, sardines, trout, herring, pilchards, tuna, etc.'; white fish as including 'cod, haddock, plaice, fish fingers, etc.' The woman was asked approximately how frequently she was currently eating each type of fish, with options: 'not at all; about once in two weeks; 1–3 times a week; 4–7 times a week; more than once a day'. Non-fish-eaters were defined as recording 'not at all' for both white and oily fish.

2.3. The outcomes

At 8 years of age, the Wechsler Intelligence Scale for Children WISC-III ^{UK} was used to assess cognitive function (Wechsler et al., 1992). A short form of the measure was employed in ALSPAC, administered in a specially designed clinic by trained psychologists as described elsewhere (Bath et al., 2013). The mean (SD) of the full-scale, verbal and performance subtests calculated in this way were: 104.0 (16.5); 107.0 (16.8); 99.5 (17.1) IQ points, respectively, and each was approximately normally distributed.

2.4. Possible confounders

We allowed for the following social factors: a continuous family adversity score which is derived from 38 factors present in pregnancy including maternal depression and anxiety; housing tenure (public housing v. rest); household crowding (no. of persons in household divided by the number of rooms available); stressful life events in first half of pregnancy (sum of 44 possible events – treated as continuous scale); smoking at mid-pregnancy (yes v. no); alcohol consumption mid-pregnancy (yes v. no); maternal age at birth; parity (no. of previous deliveries); maternal education (measured on a 5-point scale). Since the IQ measure varied with age and sex of the child, these factors were also taken into account. We did not allow for birthweight or gestation as we consider these to be likely to be on a common pathway to IQ. Since there is considerable evidence that breast feeding has a beneficial effect on the child's IQ, and there is also evidence that the type of mother who chooses a good diet with the inclusion of fish is one who also chooses to breast feed, this indicates that breast feeding should be taken into account, regardless of whether a mediator or a confounder. If this is inappropriate then the real benefits of mercury levels will have been reduced in size, but it is unlikely to hide adverse effects.

2.5. Statistical analyses

Multiple regression was used for IQ measured as continuous, and logistic regression for the lowest quartile of the score. Results are given for Model A (allowing for age at testing and sex); and Model B (additionally allowing for the confounders). Model C additionally also allowed for selenium as a sensitivity analysis to determine whether a moderator. The analyses were repeated according to whether the mother had eaten fish or not prenatally and tested for interaction; a similar exercise tested whether there was a sex difference. Since we do not consider that the data are missing at random, we have not included analyses concerning missingness. The analyses were carried out using STATA (version 14.1).

3. Results

3.1. Unadjusted analyses

We have shown elsewhere that there were no differences between the women for whom a trace metal result was obtained compared with the rest of the population in relation to their seafood intake or dental treatment (Golding et al., 2013, 2016). In Table 1