Should children with developmental and behavioural problems be routinely screened for lead?

G Lewendon, S Kinra, R Nelder, T Cronin

Abstract

***Aim*—To test the hypothesis that children with behavioural and/or developmental problems have significantly higher blood lead concentrations than the general childhood population.**

***Methods*—Blood samples were taken from 69 children with behavioural and/or developmental problems and 136 controls (children admitted for elective day case surgery under general anaesthetic). Blood lead estimations were carried out using graphite furnace atomic absorption**

***Results*—Children with behavioural and/or developmental problems had higher lead concentrations than controls, both in terms of their distribution across the group ($mean_{geometric}$ lead concentrations: 40.7 (cases), 29.2 (controls), ratio of the $means_{geometric}$ 1.35 (95% CI 1.17, 1.58)) and the proportion of children with lead concentrations above those commonly defined as "toxic"—that is, 100 µg/l (12% (cases), 0.7% (controls); $p < 0.001$). Multiple linear regression suggested that this difference was not explained by differences in age, sex, or socioeconomic status of the two comparison groups.**

***Conclusions*—Children with behavioural and/or developmental problems are more likely to have significantly higher blood lead concentrations than the general childhood population. Lead, a known and more importantly, a treatable neurotoxin, would further contribute to the impairment suffered by these children. We argue that this group of children should be routinely screened for lead.**

(*Arch Dis Child* 2001;**85**:286–288)

Keywords: developmental problems; behavioural problems; lead; screening

South & West Devon Health Authority, The Lescaze Offices, Dartington, Devon TQ9 6JE, UK
G Lewendon
S Kinra
R Nelder
T Cronin

Correspondence to:
Dr Lewendon
gill.lewendon@sw-devon-ha.swest.nhs.uk

Accepted 6 July 2001

Lead contaminated particles can enter the body through inhalation and ingestion. Children absorb over three times as much lead as adults and are at greatly increased risk through increased mouthing behaviours such as chewing objects and sucking their fingers. Lead is a known neurotoxin in children and has been shown to adversely affect cognitive functioning and development,[1–3] with no lower threshold for blood lead concentration below which these effects do not occur.[4]

Environmental policies and legislation have been successful in reducing community lead exposure; as a result it is not considered to be an important public health problem in the UK.[5] However, in the USA there is greater public concern over lead and extensive lead screening programmes have been carried out there since the early 1960s.[6] The Centers for Disease Control, Atlanta, generally recommends that children first receive blood lead screening at 1 year of age with additional targetted screening of children considered to be high risk[7]—that is, those children living in old housing with leaded paint or with old lead water pipes, especially those with a propensity for "mouthing" behaviours.[8] In the UK children have not been similarly screened and children considered to be "high risk" do not routinely have blood lead concentrations checked.

Three children under the care of the local Child Development Centre (CDC) in South West England who were otherwise asymptomatic were, by chance, found to be lead toxic, severe enough to require treatment. All three children (an autistic child and two brothers with behavioural problems) were considered to have ingested lead from sources in their home environment. These cases suggested that environmental lead might still be a health hazard for children in the UK. The aim of our study was to determine whether children with developmental and/or behavioural problems were at increased risk of lead toxicity compared to the general childhood population.

Subjects and methods

The cases were children referred to the CDC with developmental and/or behavioural problems. A total of 72 consecutive children were enrolled over a period of six months. Those who had been living in the catchment area for less than 12 months (n = 3) were excluded. The controls were children admitted for elective daycase surgery (dental extractions, ENT treatment, and routine surgery such as herniorraphy and circumcision) to the local district general hospital. This hospital has the same catchment population as the CDC. Those controls who had previously been referred to the CDC or who had learning difficulties or chronic illness were excluded (n = 4).

A blood sample was taken from each case as part of the routine investigations that were carried out when referred to the paediatrician. A 2 ml aliquot of venous blood was collected in clean dried EDTA bottles and frozen within six hours of obtaining the samples. The frozen samples were sent at weekly intervals to the toxicology laboratory at Guy's and St Thomas

Table 1 Distribution of variables in cases (children with developmental and behavioural problems) and controls

Variable	*Cases (n = 69)*	*Controls (n = 136)*
Age (y)	5.7 (2.7)	7.1 (2.6)
% (n) females	19 (13)	54 (74)
Median lead level (interquartile range), μg/l	38 (19 to 125)	30 (10 to 76)
$Mean_{geometric}$ lead level, μg/l	40.7 (1.9)	29.2 (1.6)
Townsend material deprivation score	1.1 (3.4)	2.0 (3.5)

Results expressed as mean (SD) unless stated otherwise.

Table 2 Log of blood lead levels: multiple linear regression models

Variable	*Crude*		*Adjusted†*	
	β coefficient	*95% CI*	*β coefficient*	*95% CI*
Case*	0.30	0.15, 0.46	0.29	0.13, 0.46
Age	−0.04	−0.07, −0.02	−0.03	−0.05, 0.00
Female sex	−0.13	−0.28, +0.02	0.00	−0.15, +0.15
Townsend material deprivation score	0.02	0.00, 0.05	0.03	0.01, 0.05

*Children with developmental and behavioural problems.
†Adjusted for all other variables in the table.

Hospital NHS Trust, London. Lead estimations were carried out using the standardised technique of graphite furnace atomic absorption. A 2 ml aliquot of venous blood was obtained from each of the control children as they were being anaesthetised and was similarly analysed for blood lead concentration at the same toxicology laboratory. The laboratory staff were unaware whether the samples were from cases or controls.

The age and sex of each child was recorded. Using the child's postcode, Townsend Material Deprivation Scores were calculated as a measure of the child's socioeconomic status.[9] The Townsend score is widely used as an index of deprivation for research purposes. It uses four census variables (unemployment, overcrowding, owner occupation, and car ownership) to assess material deprivation.

SAMPLE SIZE AND STATISTICAL ANALYSIS

The required sample size was calculated using Epi-Info, version 6.04. The calculations were based on data from screening programmes in the USA,[7] assuming a case control ratio of 1:2 and odds ratio (OR) of 5, with an 80% power of detecting the difference at 5% level of significance. Lead concentrations had a lognormal distribution; therefore log lead concentrations were used for all analyses. A parametric significance test (Student's *t* test) was used to compare the means of the log lead concentrations between the cases and controls and the values were backtransformed to the original scale to calculate the ratio of the geometric means. Multiple linear regression was carried out using log values of the lead concentration as the dependent variable. Multivariate analyses followed univariate analyses by stepwise addition of the independent variables; finally interaction terms were introduced. All analyses was carried out using STATA, version 6.0 statistical package.

Results

There were 69 cases and 136 control children in the study. The controls were older and contained a higher proportion of girls compared to the children with developmental and behavioural problems (table 1). The cases also had a significantly higher distribution of lead concentrations compared to controls ($mean_{geometric}$ lead concentrations: 40.7 (cases), 29.2 (controls), ratio of the $means_{geometric}$ 1.35 (95% CI 1.17, 1.58)). The proportion of children with lead concentrations generally defined as "toxic" (over 100 μg/l) was also significantly greater among the cases (cases: 8/66 or 12%; controls: 1/137 or 0.7%; $p < 0.001$). Modelling using multiple linear regression suggested that this difference was not explained by differences in age, sex, or socioeconomic status of the two comparison groups (table 2). There was no evidence of interaction between the independent variables.

Discussion

Lead, a known neurotoxin, has been shown in numerous studies to affect the cognition and development of young children,[10–14] and there appears to be no threshold below which these effects do not occur. The evidence of an inverse association between low level lead exposure and IQ is unequivocal,[1] although the evidence of a similar association between behaviour and moderately raised lead concentrations is less clear[15 16] and highlights the uncertainty as to the real impact that lead makes on children's neurodevelopment.

Our results suggest that children with developmental and/or behavioural problems are more likely to have higher blood lead concentrations than the general childhood population. These children are also more likely to have a blood lead concentration in the range considered toxic (>100 μg/l). Factors such as age, sex, and deprivation did not appear to affect these findings.

These results are consistent with earlier studies which show higher blood lead concentrations in people with behavioural and developmental difficulties.[17] Case control studies of children with developmental and/or behavioural problems such as hyperactivity were shown to have higher lead concentrations than controls.[18] More recently Kumar *et al* in 1998, measured blood concentrations in children suffering from various neurodevelopmental disorders and in healthy children.[19] They found that mean blood lead concentrations were statistically higher in children with neurological disorders than the controls. The findings from these studies are sufficient to mark this group of children as a potential risk group for increased lead exposure.

There are two main sources of bias. Firstly, the controls were not randomly selected from the general childhood population. A hospital based study population differs from the normal childhood population. Children needing hospital treatment may be sicker and more protected by parents and are, therefore, not a representative sample. On the other hand, hospital controls are more likely to be willing to cooperate than non-hospitalised individuals, thus minimising bias as a result of non-response.

In the second instance, misclassification could be a source of bias. It is known that behavioural and developmental problems are common and that most are monitored and treated in primary care. The case definition in our study was those children with a problem severe enough to warrant a specialist's referral.

Arguably misclassification could have occurred in that better educated parents may have a lower threshold for demanding a specialist's referral for their child's slow development or behavioural problems. Conversely less well educated parents from lower social classes may tolerate developmental and behavioural problems to a much greater extent and many such children may have been included in our control group. If this was truly random misclassification then a dilution of the effect, or underestimate, of the association between lead exposure and developmental and/or behavioural problems would have occurred. Controlling for social class using an area based measure of deprivation (which has its limitations) did not alter the findings; in fact, there was only a weak association between lead concentrations and socioeconomic status in our study, unlike some other previous studies.[19]

Our study confirms previous findings that children with developmental and or behavioural problems are more susceptible to lead ingestion. Whether or not these children's higher blood lead concentrations are to some degree produced by their home circumstances or habits (such as chewing objects or sucking fingers), it is important to prevent them from handicapping themselves further by lead ingestion. This can be achieved through simple environmental measures (such as handwashing before meals, wet wiping of hard surfaces, frequent washing of soft toys, and avoiding sanding off old paint in the home) which have been shown to substantially reduce the amount of lead ingested by children.[20 21]

This study highlights the need not to be complacent. Given that inexpensive and simple control measures have been shown to be effective in reducing children's blood lead concentrations, we feel that consideration should be given by clinicians as to whether they should be routinely requesting a blood lead in children referred to them for developmental and behavioural difficulties.

1 Banks E, Ferretti L, Shucard D. Effects of low level lead exposure on cognitive function in children: a review of behavioural, neuropsychological and biological evidence. *Neurotoxicology* 1997;**18**:237–82.
2 Walkowiak J, Altmann L, Kramer U, *et al*. Cognitive and sensorimotor functions in 6-year-old children in relation to lead and mercury levels. *Neurotoxicol Teratol* 1998;**20**:511–21.
3 Brody DJ, Pirkle JL, Kramer RA, *et al*. Blood lead levels in the US population. Phase 1 of the Third National Health and Nutritional Examination Survey (NHANES 111, 1968–1991). *JAMA* 1994;**272**;277–83.
4 Needleman H. Environmental lead and children's intelligence. *BMJ* 1995;**310**:1408.
5 Pocock SJ, Smith M, Baghurst P. Environmental lead and children's intelligence: a systematic review of the epidemiological evidence. *BMJ* 1994;**309**:1189–97.
6 Schlenker TL. Targeted screening for childhood lead exposure in a low prevalence area—Salt Lake County, Utah, 1995–1996. *Morbid Mortal Wkly Rep* 1997;**47**:212–17.
7 CDC, Atlanta. Update: blood lead levels—United States, 1991–1994. *Morbid Mortal Wkly Rep* 1997;**46**:213–17.
8 Hardan A, Sahl R. Psychopathology in children and adolescents with developmental disorders. *Res Dev Disabil* 1997; **18**:369–82.
9 Gordon D, Forrest R. *People and places 2; social and economic distinctions in England*. Bristol: School for Advanced Urban Studies and Bristol Statistical Monitoring Unit, 1995.
10 Charney E, Sayre J, Coulter M. Increased lead absorption in inner city children: where does the lead come from? *Pediatrics* 1980;**65**:226–31.
11 David OJ, Clark J, Voeller K. Lead and hyperactivity. *Lancet* 1972;**2**:900–3.
12 Needleman H. The current status of childhood low-level lead toxicity. *Neurotoxicity* 1993;**14**:161–6.
13 Schwartz J. Low-level lead exposure and children's IQ: a meta-analysis and search for a threshold. *Environ Res* 1994; **65**:42–55.
14 Banks E, Ferretti L, Shucard D. Effects of low level lead exposure on cognitive function in children: a review of behavioural, neuropsychological and biological evidence. *Neurotoxicity* 1997;**18**:237–82.
15 Kahn C, Kelly P, Walker W. Lead screening in children with attention deficit hyperactivity disorder and developmental delay. *Clin Paediatr* 1995;**9**:498–501.
16 Silva P, Hughes P, Williams S, *et al*. Blood lead, intelligence, reading attainment and behaviour in eleven year old children in Dunedin, New Zealand. *J Child Psychol Psychiatr* 1988;**29**:43–52.
17 Cohen D, Johnson WT, Caparulo BK. Pica and elevated blood lead level in autistic and atypical children. *Am J Dis Child* 1976;**130**:47–8.
18 Lyngbye T, Noerby Hansen O, Trilingsgaard A. Learning disabilities in children: significance of low level lead exposure and confounding factors. *Acta Paediatr Scand* 1990;**79**:352–60.
19 Kumar A, Dey PK, Singla PN, *et al*. Blood lead levels in children with neurological disorders. *J Trop Pediatr* 1998;**44**:320–2.
20 Charney E, Kessler B, Farfel M. Childhood lead poisoning: a controlled trial of the effect of dust-control measures on blood lead levels. *N Engl J Med* 1983;**309**:1089–93.
21 Lohiya GS, Crinella FM, Figueroa LT, *et al*. Lead exposure of people with developmental disabilities: success of control measures. *Ment Retard* 1996;215–19.