Lead in Australian children

Report on the National Survey of Lead in Children

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Introduction

Aims of the survey

The aims of the National Survey of Lead in Children, as specified in the funding contract, were:

1. to ascertain the blood lead levels in a representative sample of Australian children aged 1 to 4 years (inclusive);
2. to guide any further assessment of risk and/or development of targeted risk-reduction strategies by government which may be indicated by findings of the survey; and
3. to provide a baseline for the Australian population against which the effectiveness of risk-reduction strategies may be assessed.

Genesis of the survey

At its meeting on 2 June 1993, the National Health and Medical Research Council (NHMRC), in considering the revision of the 1987 Australian guidelines for lead in Australians, emphasised its concern over exposure to lead especially in young children. The NHMRC reiterated its 1987 position that there are no benefits from human exposure to lead and that all demonstrated effects of exposure are adverse. It recommended a specific goal 'to achieve for all Australians a blood lead level of less than 10 µg/dL' (0.48 µmol/L, see Box 1 for an explanation of units), and further stated 'there is a particular urgency in reaching this level in children aged 1 to 4 because of the adverse effects of lead exposure on intellectual development'.

Surveys of sample populations were suggested, but the NHMRC did not specify which groups should be surveyed.

In July 1993, the Minister for Environment, Sport and Territories convened a Roundtable Conference of government, industry and community representatives to consider and agree to a national lead abatement strategy.

The communique from the Lead Roundtable foreshadowed studies to determine the distribution of blood lead levels in the community to monitor the effectiveness of the lead abatement strategies. Funding for a national survey of blood lead levels was included in the 1993–94 Budget for lead abatement activities.

At its November 1993 meeting, the NHMRC recommended a timetable for achieving the goals set in June. A reduction of lead in all Australians to less than 15 µg/dL was to be achieved by the end of 1998, with the exception of occupational exposures. The strategies in place to achieve this first target would result in 90% of children from 1 to 4 years of age having a blood lead level below 10 µg/dL by the end of 1998.

The Environment Protection Agency (EPA), in consultation with the Department of Human Services and Health (DHSH), approached the Australian Institute of Health and Welfare to conduct a nationwide survey of blood lead levels in a representative sample of children aged 1 to 4 years. The Institute agreed, and work commenced in mid-June 1994. The entire survey was funded by the EPA.

Box 1: Units

In accordance with modern laboratory practice, blood lead levels are expressed in SI units of micromoles per litre (μmol/L). Equivalents in the older units of micrograms per decilitre (μg/dL) have been given as well in some places to aid interpretation. Older units have been retained in quotations from other reports which used μg/dL, and conversions to μmol/L given where appropriate.

The conversions are:

1 μmol/L	=	*20.7 μg/dL*
1 μg/dL	=	*0.0483 μmol/L*

Particular values for μg/dL convert as follows:

10 μg/dL	=	*0.483 μmol/L*
15 μg/dL	=	*0.725 μmol/L*
25 μg/dL	=	*1.208 μmol/L*
55 μg/dL	=	*2.657 μmol/L*

Blood lead measurements were reported to two decimal places only. A reading of 0.48 μmol/L represents a value in the range 0.475–0.484 μmol/L and is thus more likely than not to be below 10 μg/dL. Applying this reasoning, the following equivalents have been used:

< 10 μg/dL taken as < 0.49 μmol/L
< 15 μg/dL taken as < 0.73 μmol/L
< 25 μg/dL taken as < 1.21 μmol/L
< 55 μg/dL taken as < 2.66 μmol/L

Effect of lead on neurological development

Over the past two decades, attention has focused on the possible effects of lead on neurological development, at increasingly lower levels of exposure. Many kinds of studies have been conducted in a number of countries to elucidate the toxic effects of lead on the nervous system of children.

The concentration of lead in whole blood has gained almost universal acceptance as the best available surrogate for cumulative exposure. Surveys of blood lead concentration have thus come to be regarded as measuring community exposure. However, one measurement is an inadequate characterisation of the long-term exposure of an individual (Hammond & Dietrich 1990; Edwards-Bert, Calder & Maynard 1993).

Detail of the effects of low-level exposure is beyond the scope of this report. Briefly, a sustained blood lead concentration of 0.48 μmol/L (10 μg/dL) is associated with a deficit in IQ of 1 to 3 points at age 4 (WHO International Program on Chemical Safety Task Force 1993). One recent meta-analysis (Schwartz 1994) estimated that a further decrease of 2.57 IQ points (95% confidence interval 1.77 to 3.37 IQ points) was associated with an increase in blood lead concentration from 0.48 μmol/L to 0.97 μmol/L (10 μg/dL to 20 μg/dL).

There is no evidence of any threshold blood concentration for the effect of lead on IQ. A US Centers for Disease Control (CDC) review examined data from 'Several well-designed and carefully conducted cross-sectional and retrospective cohort studies in many different countries...', concluding that no threshold for the lead–IQ relationship was discernible from these data (Centers for Disease Control 1991).

Schwartz (1994) went further. He found the slope of the blood lead–IQ relationship was higher in studies with lower blood lead concentrations: 'Given the high slopes found in the studies with mean blood levels below 15 μg/dL, it seems quite implausible that a threshold could exist in those studies at 10 μg/dL...Indeed, it is the opposite hypothesis that now deserves serious consideration.' After discussing the possibility of a logarithmic dose–response relationship he continued: 'If in fact the slope increase [sic] at lower blood levels, this will have substantial public policy implications. Measures that reduce background exposure will become quite important if this is the case. Further examination of this issue and more studies at low blood lead concentrations (and in advantaged populations) are clearly warranted.'

The WHO group was more cautious: 'Existing epidemiological studies do not provide definitive evidence of a threshold. Below the range 10–15 μg/dL, [there is increasing] uncertainty attached to any estimate of effect' (WHO International Program on Chemical Safety Task Force 1993).

All reports to date are from observational studies, and there has been no trial of whether removal of lead at any age, including prenatally, can reduce or eliminate the deficit.

The most recent meta-analysis (Pocock et al. 1994) accepts the existence of an association between lead concentration in early childhood and IQ, but argues that many observational studies have not allowed for key confounders such as IQ of parents, that the possibility of reverse causation (IQ deficit leading to higher blood lead) has not been excluded, and that at low levels of blood lead (such as those expected in this survey) the findings of individual studies are not evidence either for or against a threshold effect.

The present survey was not intended to contribute to scientific debate about thresholds or causation. It is, however, prudent public health policy to assume that there is no threshold, and that the relationship between blood lead levels and lower IQ is one of cause and effect. These assumptions are implicit in the NHMRC recommendation that all exposure to lead should be minimised. These considerations also imply that the survey should measure lead to the lowest possible concentration, and report on the entire distribution of blood lead levels.

Sources of lead exposure in Australian children

Young children have the highest blood lead levels. Lead in petrol may be a significant source of lower level exposure for urban children (Fett et al. 1992). All new Australian vehicles bought since 1986 have used unleaded petrol. In early 1995, about 43% of petrol sold contained lead, at lower average concentration than used formerly. The situation varied from State to State as indicated in Table 1.

Table 1: Percentages of petrol sales which are of leaded petrol at time of survey, and agreed maximum lead contents 1994 and 1995, by State

State/Territory	Percentage leaded Feb 95	Percentage leaded Mar 95	Maximum lead content 1994 (g/L)	Maximum lead content 1995 (g/L)
NSW/ACT	38.93	38.17	0.30 (a)	0.20 (a)
Vic	45.88	45.52	0.25 (a)	0.20 (a)
Qld	43.42	43.37	0.40	0.30
WA	40.51	41.97	0.40	0.30
SA	48.41	48.05	0.40	0.30
Tas	54.05	54.22	0.40	0.30
NT	41.44	41.83	0.40	0.30
Australia	**42.96**	**42.70**		

(a) These figures relate to the agreed maximum content of lead in fuel. To reflect the market share of brands with lower contents they should be reduced by approximately one-quarter.

Source: Environment Protection Agency, unpublished data

Deteriorating lead-based paint is considered the most dangerous high-dose source of lead exposure for pre-school children, and a child's presence in the home during removal of old paint can affect blood lead concentration (Fett et al. 1992). Sydney experience is that the material of the external walls is important; brick may never be painted, whereas timber may be repainted many times over the life of the home (Causer J 1994 pers. comm.).

What proved to be the harmful effects of exposure to lead in deteriorating lead-based paint were first reported from Brisbane in 1892, and the source of the poisoning was identified in 1904. In Queensland, perhaps because of this early scientific work, the use of paint containing lead in places where children were likely to come into contact with it, for example on walls up to 4 feet from floor level, and on balcony and stair railings, was banned in 1922, and further restrictions were imposed in 1956 (Rathus 1958).

In Australia generally, paints contained as much as 50% lead until lead compounds were replaced by titanium dioxide in exterior wall paint from 1950. Lead compounds continued to be used in indoor gloss paints manufactured until 1966, so that paint in houses constructed before 1970 may contain lead in high concentrations. The maximum concentration of lead permitted in domestic paints is now 0.25%. This limit will be reduced to 0.1% in December 1997.

Most canned food made in Australia is in welded cans. Exceptions are asparagus, where the cans are soldered with tin, and cans of unusual shapes, which may be soldered with lead. Most of these latter cans contain meat products, which are not sufficiently acidic to cause absorption of lead into the contents. There may be lead in solder in imported cans containing foods. Lead in canned foods is not regarded as a significant hazard (National Food Authority 1994 pers. comm.).

Smoking increases lead levels in domestic air (WHO International Program on Chemical Safety Task Force 1993).

Overseas studies of exposure of children to lead

Data for 1988–1991 from the US NHANES III phase 1 show very much lower mean blood lead levels and proportions exceeding various values than previously reported (Brody et al. 1994). The phasing out of lead from petrol in the United States started in 1976, and by 1983, before the young children in the US NHANES III survey were born, the total amount of lead used in US petrol was 28% of that used in 1976. In 1988–1991 the geometric mean blood lead level in US children aged 1 to 5 was only 0.17 µmol/L, 24% of the level in 1976–1980 (Pirkle et al. 1994).

The NHANES III survey sampled the whole US population. Most other studies have targeted children known or suspected to be at high risk of elevated environmental lead exposure: children from low-income families, children from inner urban areas with high traffic density or in older housing likely to contain leaded paints, or children in mining communities. It is difficult to extrapolate results from these different sampling strategies to whole populations, and the findings of these other surveys do not bear on findings of a national survey in Australia.

Anticipated findings

A recent National Review of Public Exposure to Lead in Australia (Edwards-Bert, Calder & Maynard 1993) provides a useful summary of studies from 1989 to its compilation, and estimates the percentages of children with blood lead concentrations at or exceeding various levels. Highest and lowest estimates were calculated by using the results of different studies.

None of the studies on which Table 2 below is based was of representative population samples, so the table cannot be expected to show the lead level distribution in the general population. In particular, there are no published data on lead levels in rural Australia or in Aboriginal and Torres Strait Islander children.

Table 2: Estimates of percentages of Australian children (0–4 years) with blood lead concentrations greater than or equal to those shown

	≥10 µg/dL (≥0.49 µmol/L)	≥15 µg/dL (≥0.73 µmol/L)	≥20 µg/dL (≥0.97 µmol/L)	≥25 µg/dL (≥1.21 µmol/L)
High estimate	53%	22%	8%	3%
Low estimate	26%	7%	3%	1%

Source: Edwards-Bert, Calder & Maynard 1993

The National Survey of Lead in Children was conducted nine years after the introduction of unleaded petrol in Australia. While the correspondence with the United States is far from exact, even before the fieldwork took place it was expected that the 'low estimates' in Table 2 might be too high for 1995.

Methods

General outline

The National Survey of Lead in Children was a prevalence survey of Australian children aged 1 to 4 years (inclusive) with the following features:

- a nationally representative area-based sample using Australian Bureau of Statistics (ABS) Census Collector Districts (CDs);
- prior testing of samples of all equipment for freedom from lead;
- public relations and other measures to maximise response;
- questionnaire administration in homes using a national network of interviewers with transmission of questionnaires to the Australian Institute of Health and Welfare (the Institute);
- blood collection in homes using networks of specimen collectors with experience in collecting blood from children, and transport of specimens to a single laboratory for analysis;
- a 10% sample of blood specimens also being analysed in another laboratory;
- transmission of the results of blood analyses to the Institute;
- notification by the Institute of blood lead levels to parents and, if parents so requested, to a family doctor;
- with parental consent, notification by the Institute to State and Territory health authorities of individual blood lead concentrations greater than or equal to 0.73 μmol/L (15 μg/dL), for them to investigate and take remedial public health action as necessary;
- collection of water, house dust, paint flake and soil samples from homes, with transmission of samples to the Institute for storage pending analysis of specimens in one laboratory; and
- estimation of relative abundance of lead isotopes in blood specimens where lead level was 0.73 μmol/L or greater and in environmental specimens from corresponding households.

All survey activities were considered and endorsed by the Ethics Committee of the Australian Institute of Health and Welfare in accordance with its standard practices. Participation in all stages of the survey was voluntary. Parents were able to withdraw at any stage.

Sampling

Sample size

A review of Australian surveys suggested that the standard deviation of blood lead level was likely to be less than 0.15 µmol/L, and perhaps even 0.10 µmol/L. Calculations based on the likely range of standard deviation showed that 2,000 to 2,500 blood tests would best achieve the survey objectives. However, even 1,000 blood tests would yield acceptable precision. With allowance for expected non-response, it was decided that the areas included in the survey should have a population of 4,000 children aged 1 to 4 years.

Sampling strategy

The most recent ABS population estimates by single year of age are for 30 June 1994 (ABS 1995). This is about 0.6 years before the survey commencement date, thus the population of eligible children can be estimated by taking children aged 0.6 years less than the survey age groups of ages 1 to 4 at 30 June 1994. This approximation is 0.6 of children aged 0 at 30 June 1994, all those aged 1 to 3, and 0.4 of those aged 4. This calculation yields 1,032,379 or approximately 1,000,000 children aged 1 to 4 in Australia at the time of the survey. A sample of 4,000, in which each dwelling across Australia had the same 0.4% probability of selection, was identified in multiple stages.

The ABS has divided Australia into 31,404 Census Collector Districts (CDs). For the ABS Labour Force Survey, some CDs with a small number of dwellings are pooled to create a larger CD. Pooling reduces the number of CDs to 27,673. In 'non-remote' areas, including all areas in Capital City Statistical Divisions, and in rural centres with populations of 1,000 or more, CDs contain about 300 residences. In 'bounded localities' with 200 to 999 population, they contain up to 300 residences, but in 'remote' rural areas they contain about 100 residences. Of the 27,673 pooled CDs, 24,593 are 'non-remote', and 3,080 are 'remote'.

Census Districts are geographically based and so may vary in many characteristics, including the proportion of children aged 1 to 4. Consideration was given to sampling a small number of CDs and taking all children aged 1 to 4, or alternatively to sampling a larger number of CDs and selecting some of the children aged 1 to 4. The choice between these options depended on a balance between resource requirements and loss of precision from intra-class correlation. The actual intra-class correlation within CDs was unknown when the survey was being planned, and might have had substantial impact on the standard errors of measurements.

Clearly, travel and other costs associated with data and specimen collection would be minimised by using the minimum number of CDs. On the other hand, households within any one CD are generally similar; the effect of this is that, for any given number of households to be surveyed, selection of fewer households in more CDs gives more precise estimates than selection of more households in fewer CDs.

The choice of number of CDs was also influenced by availability of both interviewers and blood collectors outside major metropolitan areas (≥ 100,000 population).

A compromise was needed. ABS provided the Institute with a 1.2% sample of 316 'non-remote' CDs. To obtain a 0.4% sample of residences, from November 1994 interviewers mapped and counted residences in each non-remote CD, and divided each CD into three parts or 'blocks', with approximately equal numbers of residences in each. One of the blocks was chosen at random by ABS regional offices for inclusion in the survey.

ABS similarly provided the Institute with a 0.4% sample of 13 remote CDs. These were to be studied in their entirety.

This arrangement resulted in a notional cluster size of 100 residences in both 'non-remote' and 'remote' areas.

Further details of the sampling method are given in Appendix 5.

Survey methods

A pilot survey was conducted in 5 CDs in South Australia in September 1994. Following this, survey procedures were modified in the light of experience.

Prior to the survey itself, the Institute contracted with 175 interviewers, all of whom had worked as interviewers for ABS, to carry out the fieldwork. All interviewers attended training sessions for the survey. They were also given detailed written instructions on all aspects of their work.

The Institute also contracted with a supplier of equipment for venepuncture, with seventeen pathology practices to provide blood collection services in various areas, and with two major hospitals for analytical services. Many staff from these organisations attended the training sessions, and those who were unable to do so were required to view a training video. All were given detailed written instructions on their tasks.

The survey was conducted in February and March 1995, approximately half of the selected CDs being surveyed in each month. Within each CD, the survey had three stages.

First stage—initial publicity

A media release seeking community support for the survey was issued a few days before fieldwork started in February 1995. The general locations of non-metropolitan areas included in the sample were listed in an attachment to this media release, which thus attracted considerable attention from regional media, especially radio, covering these areas. More than thirty radio interviews resulted.

Again to maximise response, fieldwork started with two pamphlets being left at all households in the selected blocks, one week prior to any visit. The pamphlet drop was done by the contracted interviewers. One pamphlet was prepared for the survey. It introduced the survey and briefly described what it involved. It also indicated, in Turkish, Spanish, Vietnamese, Serbian, Chinese, Croatian, and Arabic, that interviewers would be able to give further information in those languages.

The second pamphlet had been prepared by the Environment Protection Agency as part of its 'Lead Alert' campaign. It described the adverse effects of lead on children, sources of environmental lead, and how the risk of exposure could be minimised.

In remote areas where a visit was made to an isolated household to deliver the pamphlets, this stage was combined with the second stage.

Second stage—identification of sample

The interviewer next visited each residence in the selected areas up to a maximum of four times; in accordance with ABS advice the subsequent visits were at different times on different days.

These visits identified households with children aged 1 to 4 on that day. Households without children in this age range were not included in the survey. Where there were eligible children, the purpose of the survey was explained, the interviewer completed a Household Form listing all usual residents and their demographic characteristics, the visible physical characteristics of the residence, including an interviewer's estimate of the year it was built and the condition of the external paintwork. The form also identified major roads within 25 metres of the residence (for inclusion of traffic counts provided by State Main Roads Departments).

The interviewer then sought agreement from the parents to return with a blood collector for a further interview, at the conclusion of which blood would be taken from the child. Parents who agreed were left with an appointment sheet showing the time of the interview, giving instructions on how to collect a first-flush early morning sample of tap water, and also giving a 1800 Freecall number if they had any enquiries. This number was answered by Institute staff. Where parents said they would not agree to have blood taken from their child, the interviewer sought to administer immediately the third-stage questionnaire and to collect household environmental specimens (see below).

The need for interpretation in the languages provided for in the pamphlets was determined at these visits. Foreign language telephone interviews were arranged where necessary.

Where nobody was found at an apparently occupied residence after four visits, a card was left inviting the householder to telephone the 1800 number to tell the Institute whether there were children aged 1 to 4 years living at the residence. Where there were, they were invited to take part in the survey; if they agreed, the interviewer was notified and made further calls.

Contact with households was recorded in the interviewer's log so that response rates could be determined. One log book was not returned at the end of the fieldwork.

In two CDs in Broken Hill, for reasons described in the next section, the second stage was combined with most of the third stage.

To give maximum comparability with other existing data, as many as possible of the questions asked were standard questions from the Labour Force Survey, the 1990 Survey of Income and Housing Costs and Amenities, or other ABS surveys. One reason for asking some of these questions at this stage of the survey was to give parents a sense of involvement before they considered whether they should allow blood to be collected from their children. Another was to reduce the time required at the following visit, when two survey staff would be needed. It was also anticipated that some families who took part in this stage of the survey would drop out before the following one, and it was highly desirable to have some demographic information on those who would later become non-respondents.

The Household Form is included as Appendix 1 to this report. The response cards for some questions are also included as Appendix 3. Coding is indicated on the form and the response cards except for country of birth, which was coded according to the classification used in the 1991 Census (ABS 1991).

Third stage—interview, blood collection and collection of environmental specimens

Interview

To encourage response, the interview was as short as possible, but the questions needed to include confounding variables, which in most studies have been found to attenuate the crude estimate of the effect of lead on child development (Edwards-Bert, Callan, Bentley & Baghurst 1993; Pocock et al. 1994).

With the agreement of the Environment Protection Agency, some questions about diet and immunisation status were included in the questionnaire at the request of other agencies.

Foreign language interviews were conducted by telephone as necessary. Translations of the questionnaires were available to interpreters.

As with the Household Form, to the maximum extent possible, questions used were taken from ABS surveys. Interviewers wrote responses in boxes. All questions were self-coding. The Questionnaire itself is included as Appendix 2. Response cards for some questions are included as Appendix 3.

Outcome of interviews

The effort put into field documentation and interviewer training meant that the interviews were nearly always carried out in accordance with instructions. The only known breach of instructions by an interviewer occurred in February 1995, as the survey was getting under way. An interviewer contacted the Institute to say that she had, for reasons of confidentiality, destroyed three household forms where the parents had not agreed to collection of blood.

Blood collection

Private and public sector organisations were invited to tender to supply skilled paediatric blood collectors and to transport blood to a central laboratory for analysis. Blood was to be cooled from the time it was drawn, and except where it was collected sufficiently close to the laboratory performing the analysis, was to be airfreighted to that laboratory in cooled containers meeting the usual air transport standards.

Tenders were to relate to major cities, to rural areas of mainland States, and to the whole of Tasmania, the Australian Capital Territory, and the Northern Territory. No tenders were received from many areas, and after tenders had been let, individual pathology practices were approached to fill these gaps. This proved a difficult task for some rural CDs. In all, seventeen pathology practices were contracted.

The interviewer and the blood collector attended each home together for collection of specimens. The skills of the survey staff in obtaining agreement to sample blood and of the blood collectors in obtaining samples with minimal trauma to the children were crucial to the success of the study. To maximise response rates and the likelihood of obtaining adequate samples (4 mL) of blood, the environment had to be as secure and non-threatening to the child as possible. Blood collection was therefore performed in the home.

It had been found (Causer J 1994 pers. comm.) that if one person spent time quietly with the child and gained the child's confidence, the frequency of distress during venepuncture decreased significantly. It was hoped that this would also reduce the frequency of children refusing to have blood collected.

During this time, the interviewer could discuss the study with the parents, complete the questionnaire, and obtain written consent to take blood. Parents were promised that they would be told of the blood test results and their interpretation. Their permission was also sought to notify State and Territory health authorities of blood lead concentrations exceeding levels notifiable by statute; this was done because the confidentiality sections of the Australian Institute of Health and Welfare Act made it illegal to notify high lead levels without parental permission. If parents wished, test results were also sent to a nominated medical practitioner.

The ubiquity of lead in the environment made contamination of specimens during collection a potential source of major error. For this reason, it was essential that blood sampling was performed in a uniform manner. One instance of possible contamination was identified (see Case 18, Appendix 4).

Blood was collected in 4 mL draw Greiner vacuettes with EDTA anticoagulant. Collectors had the choice of a butterfly needle and tube set leading directly to the vacuum container, or of a needle and syringe; those who used the needle and syringe punctured the cap of the EDTA container with the needle, and allowed the vacuum to draw the blood in. Tubes were inverted several times immediately after collection of the specimen to prevent clot formation.

Collectors also had to adhere to Australian standard AS 2636 'Sampling of venous and capillary blood for the determination of lead or cadmium concentration' as it related to venepuncture. The only variation was that it was recognised as unlikely that children could sit still for 10 minutes, so the survey requirement was that the children were encouraged to be quiet while their parents were interviewed.

At the end of each day's sampling, blood samples were refrigerated and airfreighted in a cool container to a central laboratory for analysis. Storage requirements were those of AS 2636.

Blood collection in Broken Hill

The survey sample included two CDs in Broken Hill where there is a well-established lead abatement program. Special arrangements were required to avoid disruption of this program.

Blood collection was carried out only if there was no recent (within 6 months) blood sample; otherwise the most recent blood reading was used. Blood collection and interviews were carried out in cooperation with the Broken Hill Environmental Lead Centre.

Outcome of blood collection and transport of blood

The tender specifications required blood to be transported by air to Sydney in containers which were both acceptable for air transport and cooled. Blood collected in Sydney or nearby was to be cooled from collection and delivered by the contracting laboratories' usual courier services. At the Institute's request, the laboratory at the Royal North Shore Hospital (RNSH) noted the condition of the blood at time of receipt, recording up to three problems with each specimen (Table 3).

Of the 1,576 specimens received by RNSH, 853 (54%) contained sufficient blood in good condition with no inconsistencies between specimen label and request form.

The most frequent problems related to cooling of specimens, and the lack of cooling or inadequate cooling was a major cause of the haemolysis noted in Table 3. Although lack of cooling would not have affected the measurement of blood levels of lead or other heavy metals, haemolysis did impact on ability to measure the haematocrit.

Clotting of the specimen occurred in 51 instances. There is no evidence that this had any effect on the measurement of blood lead level. The mean lead reading for clotted specimens was 0.253 µmol/L compared with 0.277 µmol/L for specimens without clots (t-test on log-transformed values = 0.25, p = 0.25).

None of the other problems noted would have affected measurements relating to blood lead level. They do, however, have major implications for the conduct of other national surveys involving collection and transport of blood specimens. The problems have therefore been described in Appendix 6.

Table 3: Number of blood specimens received with various characteristics

Characteristic	Blood specimens Number	Blood specimens Per cent
Good condition and with consistent labelling	853	54.2
Ambient temperature — shipped and received	249	15.8
Ambient temperature — received with cooling packs	221	14.0
Ambient temperature — from Sydney region	61	3.9
Clots	51	3.2
Haemolysed (+)	75	4.8
Haemolysed (++)	51	3.2
Haemolysed (+++)	10	0.6
Fully haemolysed[(a)]	2	0.1
Insufficient sample for analysis[(b)]	10	0.6
Insufficient sample for haematocrit	5	0.3
Less than 0.5 mL received	34	2.2
Incomplete or inconsistent labelling etc.	92	5.8

(+) mild; (++) moderate; (+++) severe.

(a) One specimen could not be analysed.

(b) Three specimens were subsequently analysed at Royal Prince Alfred Hospital.

Collection of environmental specimens

Several environmental samples were collected at this third-stage visit.

A tap water sample was collected at the third-stage visit if the residents had not collected an early morning sample as requested at the previous visit.

A sample of house dust was taken from a 300 mm square of floor where the parents indicated the child spent most of its time. This standard method gives a measure of lead available to the child (Lanphear et al. 1995). Briefly, a 300 mm square template was dropped onto the floor, and tape put around its edges. The template was removed. Wearing a disposable glove, the interviewer wiped the marked square in two directions with a 'baby wipe'. This was then put into a clean container.

Garden soil samples were taken from as close as possible to the wall at the rear of houses, under a window if there was one. If this area was grassed, a small section of lawn was removed. A sample was also collected from any area indicated by parents as where the child plays. An apple corer was used to obtain the specimens, all of which were dropped into the one clean container. If the area was fully paved, dirt and dust scrapings were collected instead with a plastic knife. No sample was taken from multistorey flats with no garden area.

Finally, if badly peeling paint was noted, a paint flake was scraped into a clean container using a plastic knife. A window sill was suggested as the most suitable place to sample, because it was a site very likely to show peeling, and because the paint used on window sills was considered more likely than other paint to contain lead.

Outcome of environmental specimen collections

Specimens of one or more of dust, soil, water and paint were taken from 2,186 of the 2,215 households in the survey and from 1,290 of the 1,300 households of children from whom a blood sample was taken (Table 4).

Dust was recorded as collected by wipe from floors in 2,180 households, most commonly from carpet or rug.

Table 4: Sources of dust samples

Floor surface	Number	Per cent
Carpet or rug	1,667	76.5
Wood	127	5.8
Linoleum	162	7.4
Ceramic	96	4.4
Other specified	84	3.9
Not stated	44	2.0
Total	**2,180**	**100.0**

Soil specimens were collected from 2,113 households, and in a further 52 (high-rise buildings or homes with no identifiable back yard) the interviewer noted that no specimen was required.

At the end of the visit which identified eligible children, the household was left with a specimen jar for collection of first-flush early morning water. The time of collection was noted; 1,503 of 2,186 households are recorded as having remembered to collect water in this way. In almost all the remaining cases it was collected at the final visit.

In 1,891 households, mains water was the sole source; in the remainder, water came from another, or more than one, source. The sources are shown in Table 5.

Table 5: Sources of water samples

Source of water sample	Number	Per cent
Mains/town water	1,891	86.5
Town water and rainwater tanks	64	2.9
Town water and other sources	13	0.6
Rainwater tank only	127	5.8
Rainwater and other sources	10	0.5
Dam water	1	0.0
Bore water	4	0.2
Other sources	11	0.5
Source not stated	65	3.0
Total	**2,186**	**100.0**

Paint specimens were obtained from 663 households, with the interviewer noting that they were not required from 1,376 households where there was no peeling paint. The sources of the specimens are shown in Table 6.

Table 6: Sources of paint samples

Source of paint sample	Number	Per cent
Window	201	30.3
Skirting board	18	2.7
Wall	244	36.8
Other	183	27.6
Source not stated	17	2.6
Total	**663**	**100.0**

Equipment

Items such as baby wipes, adhesive bandages, plastic knives and apple corers were purchased from the usual outlets for these products. The apple corers for soil sampling and the plastic knives used as scrapers for paint sampling were tested for lead before a decision was made on which brand would be used in the survey. None had significant concentrations of lead.

To determine which baby wipe should be used for testing lead burden on floors, packets of all available brands of baby wipes were purchased. Sample wipes were digested and analysed for lead at the Australian Government Analytical Laboratories. The brand chosen, 'Johnson's baby washcloth', had 0.019 μg of lead per tissue. The next lowest level found was 0.060 μg, and other brands had lead levels ranging up to 3.32 μg.

There was a tender for a single supplier of specialised equipment which might come into contact with any specimen, blood or environmental. All such equipment was required to be tested and determined to be lead-free in accordance with AS 2636. The equipment so tested included the EDTA tubes, the specimen jars used for environmental samples, and all equipment used in venepuncture including the cleaning pads.

The tender for supply of specialised equipment specified testing for lead and delivery by mid-December 1994. Shortly after fieldwork started in February 1995, it was discovered that 2.5 mL syringes had been supplied rather than the 5 mL syringes ordered (the aim was to collect 4 mL of blood); replacements could not be arranged until the February blood collections were nearly complete. We are grateful to blood collection and coordinating staff for their tolerance of this change. The lower maximum volumes of specimens collected earlier in the survey would not have affected measurement of blood lead levels, but would have reduced the amount of blood available for other purposes.

The specimen jars were also not delivered until fieldwork was starting; again, considerable logistic problems resulted.

Laboratory analysis

Lead analysis methods

Lead in blood

All blood specimens were analysed for lead and measured for haematocrit at the Royal North Shore Hospital of Sydney (RNSH).

A 10% sample of blood specimens was analysed for quality control purposes at the Royal Prince Alfred Hospital (RPAH), also in Sydney. This laboratory also stored leftover blood, carried out the analysis of environmental specimens as required, and tested all equipment for lead prior to the survey.

The RNSH laboratory analysed blood lead by graphite furnace atomic absorption spectroscopy (GFAAS), the most commonly used procedure, in accordance with Australian standard AS 4090. The samples were diluted with a matrix modifier solution containing ammonium phosphate and a surfactant. An aliquot of the diluted sample was atomised in a graphite furnace atomic absorption spectrophotometer workhead. This method is applicable to determination of lead concentration in blood in the range 0.1 to 2.5 μmol/L.

The Australian standard AS 4090 test for blood lead concentration has a standard deviation of estimate of about 0.02 μmol/L (0.5 μg/dL, calculations based on Threlfall et al. 1993) or 0.05 μmol/L (1 μg/dL, Waller G, Chair SAA Committee, 1994 pers. comm.). The RNSH laboratory has a within-run coefficient of variation of 5% at a lead concentration of 0.8 µmol/L. The between-run coefficient of variation is 7% at 1.9µmol/L. Because of this variation and the known clinical uses of blood lead estimation, the laboratory usually reports its findings to 0.1 µmol/L, and states its detection limit as < 0.1 µmol/L. Because of the requirement for manipulation of survey data, the laboratory agreed to report all blood lead levels to 0.01 µmol/L and to use a detection limit of 0.04 µmol/L.

As more than 95% of lead in blood is found in red cells (WHO International Program on Chemical Safety Task Force 1993), many earlier studies also measured the haematocrit, and related the measurement to red cells, lead in which is in equilibrium with lead elsewhere in the body. However, haemoglobin levels in children are closely clustered, so that any corrections would have been small (Duggin GG 1994 pers. comm.). Although there was little need to measure haematocrit, it was done so that statistical analysis could be carried out on both corrected and uncorrected blood lead levels, to maximise opportunities for comparison with other studies.

At RPAH, blood lead levels were measured by inductively coupled plasma mass spectrometry (ICPMS). Lead was measured directly in whole blood after dilution in ammonium EDTA-based diluent using platinum and rhodium as internal standards. Pig blood was used to construct a matrix-matched standard curve. For lead, the method is calibrated up to 2.4 µmol/L. Within-run precision is about 1% at a level of 0.2 µmol/L and about 2% at a level of 2.0 µmol/L. Between-run precision is about 9% at a level of 0.2 µmol/L and about 3.5% at 2.0 µmol/L.

ICPMS analysis was carried out on all specimens where the last digit of the number of the RNSH pathology request form was a '9'. This analysis also yielded levels of selenium, zinc, copper, mercury, cadmium, bismuth, antimony, arsenic, and thallium in each specimen, but these findings are not included in this report, which relates only to lead.

Lead in environmental specimens

Specimens analysed

Because environmental specimens could be tested by the Royal Prince Alfred Hospital laboratory at only a limited rate, and not all specimens could be analysed in time for findings to be included in this report, testing was prioritised.

After consultation with the Environment Protection Agency as to priorities, the following environmental specimens were analysed in time for findings to be included in this report:

- specimens from all households where any child had a blood lead level greater than or equal to 0.49 µmol/L;
- all specimens from South Australia, Tasmania, the Australian Capital Territory and southern New South Wales (parts where survey administered from ABS Canberra office), and the Northern Territory, whether or not blood was collected at that household; and
- a systematic random sample of specimens from the remaining households in Western Australia, Queensland, Victoria or the rest of New South Wales where the number allocated to the Household Form on receipt ended in the digits 0, 4, 5 or 9.

Lead in house dust

The method used was developed in the Trace and Toxic Element Unit of the Clinical Biochemistry Department, RPAH. The wipes were digested with concentrated nitric acid (Merck Suprapur) in a sandbath, diluted with clean water, mixed, centrifuged, separated from debris and analysed by ICPMS against an aqueous standard curve. Certified reference material (soil) was added to a 'blank' wipe to act as quality control material and analysed every 20 specimens.

Lead in soil

The method used was developed in the Trace and Toxic Element Unit of the Clinical Biochemistry Department, RPAH. All soil specimens were dried at 65°C for 24 hours and then passed through a 1 mm sieve with vegetation and gravel being discarded. The samples were then digested in concentrated nitric acid (Merck Suprapur) in a sandbath, diluted with clean water, mixed, centrifuged, separated from debris, and analysed by ICPMS against a standard aqueous curve. Certified reference material and internal quality control material were run every 20 samples.

Lead in water

The method used was developed in the Trace and Toxic Element Unit of the Clinical Biochemistry Department, RPAH. All samples were acidified to 1% (v/v) with concentrated nitric acid (Merck Suprapur) prior to analysis. Lead content of water was then measured, by direct injection of water into an ICPMS, against a standard aqueous curve. Standard reference material and internal quality control material were run every 15 samples.

Lead in paint

The method used was developed in the Trace and Toxic Element Unit of the Clinical Biochemistry Department, RPAH. Paint samples were dried at 65°C for one hour and ground to a fine powder using a mortar and pestle. The powder was digested with concentrated nitric acid (Merck Suprapur) in a sandbath, diluted with clean water, mixed, centrifuged, separated from debris, and analysed by ICPMS against a standard aqueous curve. Certified reference material and internal quality control material were run every 10 specimens.

Lead in cigarettes

A relationship between smoking in the household and children's blood lead levels was found in the initial analyses. In subsequent multivariate analysis smoking remained a risk factor. It was therefore decided to test some Australian cigarettes for lead content.

Ten brands of cigarettes were tested by Australian Government Analytical Laboratories, Sydney. Five cigarettes (including wrapping paper) from each pack were cut into small pieces by scissors and mixed thoroughly. One gram of sample was digested in 10 mL of nitric acid. After making up to 40 mL, lead was determined by ICPMS.

Isotope studies of blood and environmental specimens

The Environment Protection Agency arranged with the CSIRO Minerals Research Laboratories and the Institute that the relative abundance of isotopes of lead be determined in the blood specimens with lead levels of 0.73 μmol/L and over and in environmental specimens from the households in which the children with these blood lead levels lived. These 'fingerprinting' techniques can demonstrate the source of blood lead.

There were 27 children with blood lead levels of 0.73 μmol/L and over; two of these were from Broken Hill and no blood specimens were available. For the remaining 25, RPAH provided red cell (20) or whole blood (5) samples. These samples were digested in concentrated nitric acid (ultra-clean) and the lead was purified by anion exchange chromatography.

The corresponding soil, house dust, and paint samples had already been partly digested in nitric acid at RPAH. They were further digested in sub-boiling concentrated nitric acid and then converted to bromides. The water specimens were also converted to bromides. Lead separation using anion exchange chromatography was carried out, and in the case of the paint and soil samples the 'coarse' lead separation was followed by anodic deposition to achieve a 'pure' separation.

High precision isotopic ratios for all samples were measured on a VG Isomass 54E thermal ionisation mass spectrometer. The standard deviation of the $^{206}Pb/^{204}Pb$ ratio is 0.05% based on more than 1,700 analyses of the international lead standards SRM981 and SRM982, and replicate analyses of natural samples. For comparison with other isotope laboratories, the data have been normalised by a correction of +0.08% per mass unit.

Model for bioavailability of lead in paint

Solubility of lead from paint flakes was measured in specimens from homes where any child had a blood lead level of 0.49 μmol/L and over and where the lead concentration in those flakes exceeded 10,000 mg/kg (1%).

No attempt was made to separate the paints into their constituent layers. The samples were crushed in an agate mortar and pestle to pass through a nylon sieve of 100 μm mesh size. This size fraction was used because it is known to be extremely difficult to remove from hands. Also, recent experiments have been performed on material with a mean size of about 50 μm.

Lead concentration in the particles was measured by inductively coupled plasma emission spectroscopy (ICPES) by Graeme Waller and Associates. 'Bioavailability', or more correctly, solubility, of the lead in the paint samples was measured by leaching the crushed and sieved particles in 0.1 M hydrochloric acid for two hours, and measurement by Graeme Waller and Associates of the amount of dissolved lead, again by ICPES. These tests are intended to simulate the absorption of a proportion of the lead in the gastro-intestinal tract. The proportion of the lead in the particles which is dissolved in the acid is potentially available for absorption, hence the use of the term 'bioavailability'.

Notification of findings

Once the relevant files had been linked, and the data were regarded as sufficiently valid for the purpose, letters were sent to all parents advising them of the results of tests on their children. Where the results were legally notifiable to State and Territory health authorities and the parents had consented to this, notifications were made at the same time.

Letters to notify family doctors of findings were also sent, where parents had requested this.

Telephone enquiries

To improve the running of the survey, the Institute established a 1800 Freecall line, the number for which was shown on survey literature. Over the eight-week period of fieldwork this attracted 621 calls, an average of 15 per working day. Nearly half of the calls were from potential respondents who had not been at home on any of four occasions when interviewers called. They had been left a card inviting them to ring and say whether children eligible for the survey were living at their residence.

The sources of these calls are shown in Table 7.

Table 7: Nature of telephone queries during survey fieldwork

Source/nature of telephone query	Number
Interviewer	138
Respondent	126
Pathology laboratories	13
Blood collector	12
Australian Bureau of Statistics	22
Interpreter	10
Request for interpreter	12
Respondent to non-contact card	
– with children	29
– without children	245
Other	14
Total	**621**

Foreign language interpretation

Survey documents were available in Spanish, Chinese (Mandarin), Vietnamese, Croatian, Serbian, Turkish and Arabic. In a small number of instances the interviewer, having the translated survey material, was able to conduct the interview. Three Sydney interviewers are known to have used their skills in Serbian, Croatian and Spanish in this way.

Requests to the Institute from interviewers for assistance with foreign language interpretation were recorded. Twelve requests were received, two from Adelaide and the remainder from Sydney. Four of these requests were for assistance with Chinese-speaking households and eight were for assistance with Vietnamese-speaking households. Interviewers were obtained, but three households refused further participation and two more could not be contacted again; blood specimens were obtained from children in six of the remaining seven households.

Statistical analysis

Univariate and bivariate analyses were carried out using SAS 6.09 (SAS Institute 1990a, 1990b). GLIM 4 was used for multiple linear regression and logistic regression modelling (Francis et al. 1993).

Modelling by multiple linear regression was undertaken for the total number of valid blood results using variables derived from questions, or combinations of questions, included in the Household Form and the Questionnaire. Blood lead concentration is skewed to the right because no value can be less than zero and there is usually a long tail of outlying high values. This was the case for the present survey, so blood lead levels were transformed to natural logarithms. This gave an approximately normal distribution, necessary for a valid analysis. Residual analysis supported the assumptions of linearity, normality of error terms and constancy of error variance.

A logistic regression was carried out to assess the possible contribution of each of the factors in the linear regression model on the likelihood of having a blood lead level of 0.49 μmol/L or higher.

In each case, the final model included only covariates which could not be deleted from the model without a statistically significant change in error variance (termed deviance in GLIM) at the 5% level, as shown by the appropriate F-statistic or likelihood ratio chi-squared statistic. Similarly, the addition of any remaining covariate to the final model did not result in a statistically significant decrease in deviance.

Two types of regression analysis which included environmental variables were done. Environmental specimens were tested for all households where any child had a blood lead level greater than or equal to 0.49 μmol/L. These children were all included in a logistic regression along with a systematic random sample of the remaining children (with blood lead levels less than 0.49 μmol/L) from all States and Territories. This is analogous to a case-control study in which the children with high blood lead are the cases, and those in the random sample are the controls.

Secondly, a linear regression for log blood lead was undertaken which included all children with blood lead data from the four smallest States and Territories (South Australia, Tasmania, the Australian Capital Territory and the Northern Territory) and a systematic random sample of children of both high and low blood lead levels from the four largest States (New South Wales, Victoria, Queensland and Western Australia).

The distributions of lead levels in dust, soil, water and paint were all highly skewed and were transformed to natural logarithms in all analyses.

Due to the possible correlations between children living within the same CD and children from the same households, regression models including random effects terms for CDs and households within CDs were fitted using the REML (residual maximum likelihood) procedure in GENSTAT 5 (Genstat 1994). The corresponding GLMM (general linear mixed model) procedure from the same package was used for fitting corresponding logistic mixed models on the dichotomised outcome using the marginal method of Breslow and Clayton (1993).

The best models identified in the standard regression analyses were refitted with the extra variance terms in GENSTAT.

Results

Response rates

Using ABS statistics of Census Collector District (CD) size, it was estimated from the survey design that 26,090 dwellings would be visited. In fact, interviewers located 27,348 with differences occurring in known growth areas. Occupants of 26,193 of these dwellings were contacted either by the interviewer or by telephone to the Institute where the interviewer had left a card. Some of the remaining 1,155 dwellings would have been vacant, and there would also have been some where no contact was made by interviewers and occupants did not respond to the card inviting them to telephone the Institute.

It was also estimated from the sample design that 4,112 children aged 1 to 4 years lived in the selected areas, but only 3,542 were located in 2,886 households. Some children would have lived in the 229 dwellings where occupants refused all details and the 1,155 where no contact was made (total 1,384 dwellings), but it is not possible to make a reliable estimate of their number.

Survey forms were completed only after the interviewer had established the residence of children aged 1 to 4 years in the household. Both a Household Form and a Questionnaire were returned from 2,215 households with 2,807 children. A Household Form with at least some information, but no Questionnaire, was returned from a further 202 households with 246 children (Table 8).

Table 8: Response rates in households with 1–4-year-old children resident

	Households		Children 1–4 years	
Type of response	**n**	**%**	**n**	**%**
Household Form and Questionnaire both completed				
With blood sample analysed	1,300	45.0	1,575	44.5
Without blood sample analysed	915	31.7	1,232 [(a)]	34.8
Household Form only				
Part refusal	154	5.3	184	5.2
Part non-contact	48	1.7	62	1.7
Household Form not completed	469	16.3	489	13.8
Total	**2,886**	**100.0**	**3,542**	**100.0**

(a) Includes 101 children in 99 households in which at least one other child had blood taken.

Attempts to obtain blood samples, the quantity of blood obtained, and reasons for failure to obtain a specimen were all recorded on the Household Form or the Questionnaire, although these details were not always consistent with those recorded on the request for analysis of the blood specimen.

For one-third of the children (927) for whom Questionnaires were completed, parents refused permission to venepuncture. In another 183 instances where parental consent was given, the child refused to cooperate and collection was not attempted, or was abandoned after the child became distressed during an unsuccessful attempt. A full sample was obtained in approximately two-thirds of attempted venepunctures (Table 9).

The 1,575 children from whom blood was successfully taken came from 1,300 households and there were 1,043 households with one child from whom blood was collected, 242 with two children, 12 with three children and three households with four children. In 99 households there were at least one child who provided a blood sample and at least one child who did not.

Table 9: Numbers and percentages of children by consent to obtain blood sample, and volume of specimen

Outcome	Number	% of children	% of samples
Sample obtained			
Full 4 mL sample	1,057 (a)	37.7	66.7
Less than 4 mL sample	504 (b)	18.0	31.8
Volume of sample not recorded	14 (c)	0.5	0.9
Could not be analysed	9 (d)	0.3	0.6
Sample not obtained			
Child unwilling	183	6.5	
Parent refused	927	33.0	
Non-contact	11	0.4	
Other reason	67	2.4	
Reason not given	35	1.2	
Total	**2,807**	**100.0**	**100.0**

(a) Includes three samples analysed by the collecting laboratory in error.

(b) Includes three samples insufficient for analysis at Royal North Shore Hospital but subsequently analysed by Royal Prince Alfred Hospital.

(c) Includes four samples previously analysed by Broken Hill Environmental Lead Centre.

(d) Includes one sample which was never received, seven for which there was insufficient volume and one which was completely haemolysed.

The possibility of response bias is investigated later in this section.

Blood lead levels in Australian children

For all 1,575 specimens, the arithmetic mean blood lead level was 0.277 µmol/L (5.72 µg/dL), with standard deviation 0.151 µmol/L (3.13 µg/dL). The distribution of blood lead levels is shown in Figure 1. The geometric mean blood lead level was 0.244 µmol/L (5.05 µg/dL). The distribution of blood lead levels transformed to natural logarithms is shown in Figure 2.

Of the 1,575 blood lead readings, 1,460 (92.70 %) were less than the NHMRC target level of 0.49 µmol/L (10 µg/dL) and 115 (7.30%) were greater than or equal to this level. The estimate for the total Australian population, 7.25% with a standard deviation of 0.00676, is almost identical (see Appendix 5 for details of calculation). This represents about 75,000 children aged 1 to 4 years in Australia with blood lead of 0.49 µmol/L or higher, from an estimated population of about 1,035,000.

Only 27 children (1.7%) had readings equal to or greater than 0.73 µmol/L (15 µg/dL) and thus potentially notifiable to State and Territory health authorities. These children are discussed in detail in Appendix 4. Four readings were equal to or greater than 1.21 µmol/L (25 µg/dL). The highest reading was 1.58 µmol/L (32.7 µg/dL).

The lowest level measured was below 0.04 µmol/L, the limit of detection in the Royal North Shore Hospital laboratory. This single reading has been treated as 0.02 µmol/L in all analyses.

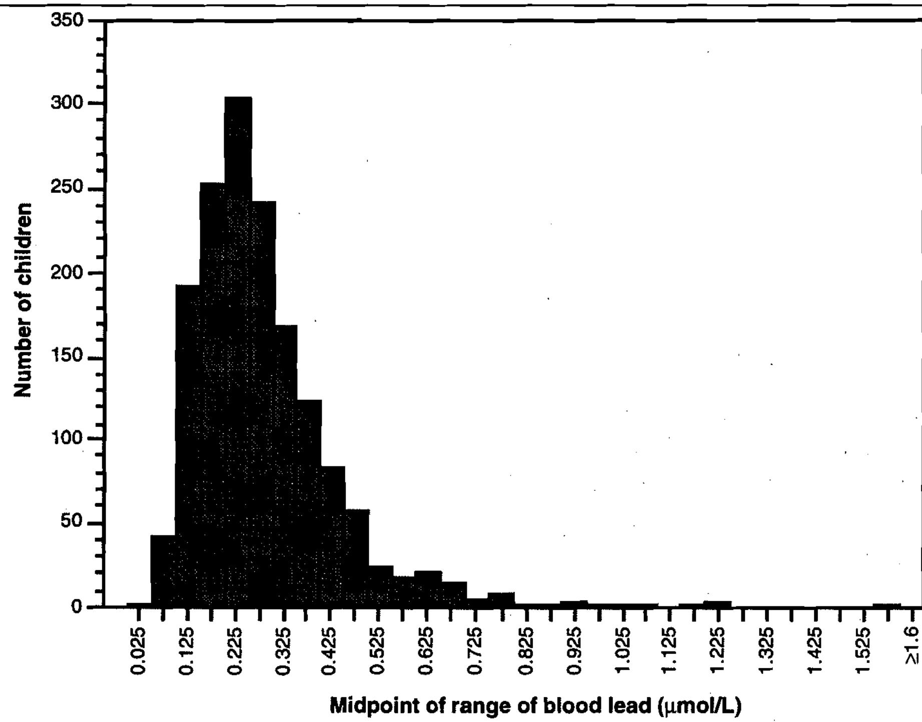


Figure 1: Distribution of blood lead levels for 1,575 Australian children, aged 1 to 4 years

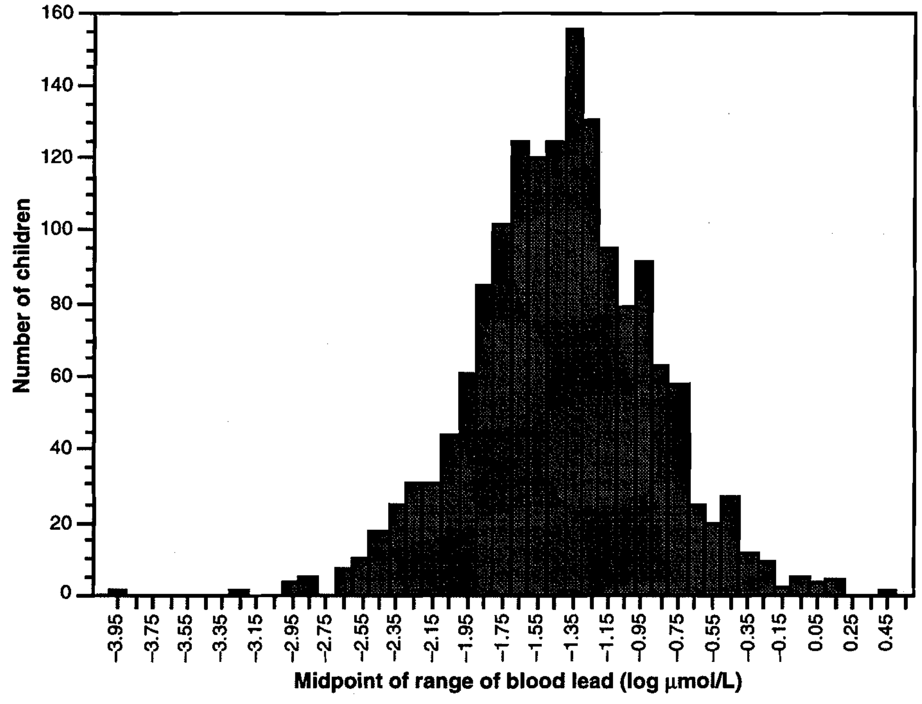


Figure 2: Distribution of log-transformed blood lead levels for 1,575 Australian children, aged 1 to 4 years

Single-variable analysis of factors affecting blood lead concentration

These first presentations of findings are by single factors only and are not adjusted for intervening factors. Regression analyses which adjust for intervening factors are presented later. The factors are grouped according to whether they are demographic and social factors affecting the household, physical and environmental factors affecting the household, and factors affecting the individual child. The distinction between the first two groups is not always clear.

Demographic and social factors relating to the household

State or Territory of residence

The lowest mean levels were found in the Australian Capital Territory, where the areas sampled were mainly newly settled, and only one CD had been settled when significant concentrations of lead was used in house paint. The mean levels were lower in Queensland and Victoria than in other States. The highest mean blood lead levels were from the Northern Territory and South Australia (Table 10).

Table 10: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by State or Territory of residence

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
State or Territory	Mean	se	n	%	n	%	n	%
NSW	0.28	0.01	395	91.7	36	8.4	431	100.0
Vic	0.27	0.01	324	93.9	21	6.1	345	100.0
Qld	0.27	0.01	257	95.2	13	4.8	270	100.0
WA	0.29	0.01	162	89.5	19	10.5	181	100.0
SA	0.30	0.01	123	92.5	10	7.5	133	100.0
Tas	0.28	0.02	119	92.3	10	7.8	129	100.0
ACT	0.22	0.02	62	95.4	3	4.6	65	100.0
NT	0.32	0.03	18	85.7	3	14.3	21	100.0
Australia	**0.28**	**0.00**	**1,460**	**92.7**	**115**	**7.3**	**1,575**	**100.0**

Sex of child

Blood lead level does not appear to be influenced by the sex of the child (Table 11).

Table 11: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by sex of child

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Sex of child	Mean	se	n	%	n	%	n	%
Male	0.28	0.01	728	91.7	66	8.3	794	100.0
Female	0.27	0.01	732	93.7	49	6.3	781	100.0

Age of child

Mean blood lead level decreases progressively from 1 year of age to 4 years (Table 12). The peak lead level is at ages 15 to 17 months (Figure 3). The proportion of children with blood lead levels of 0.49 μmol/L or more decreases more rapidly than the mean level.

The geometric mean blood lead level shows a similar pattern with age.

Table 12: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by age

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Age	Mean	se	n	%	n	%	n	%
1 year	0.31	0.01	300	89.8	34	10.2	334	100.0
2 years	0.29	0.01	400	90.1	44	9.9	444	100.0
3 years	0.26	0.01	394	93.6	27	6.4	421	100.0
4 years	0.25	0.01	366	97.3	10	2.7	376	100.0

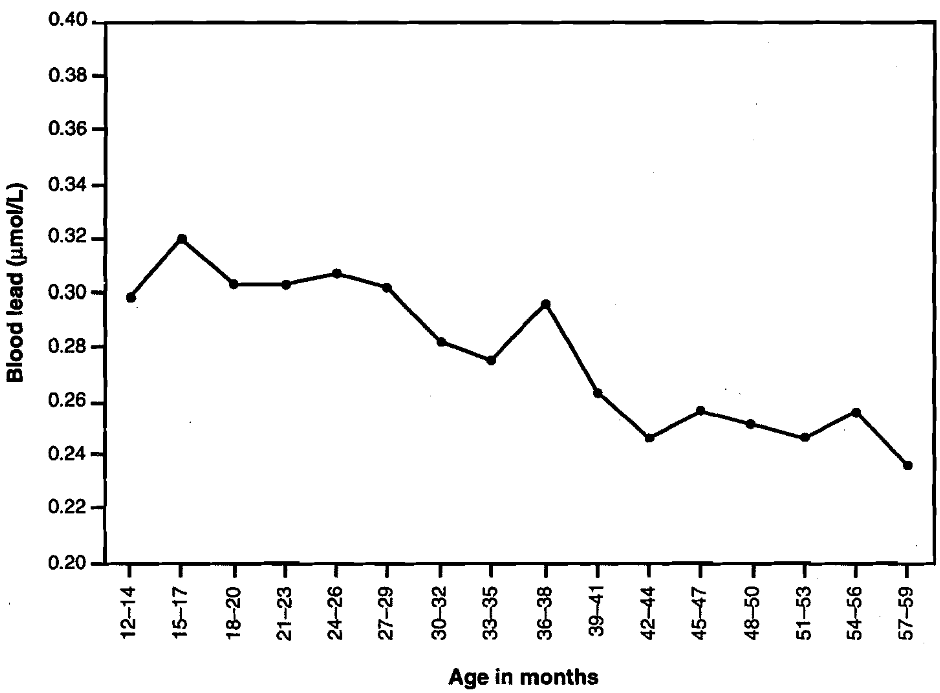


Figure 3: Mean blood lead level by age group

Aboriginal and Torres Strait Islander children

Blood lead levels are higher in Aboriginal and Torres Strait Islander children than in other Australian children (Table 13).

Table 13: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by identification as Aboriginal or Torres Strait Islander

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Aboriginal or Torres Strait Islander	Mean	se	n	%	n	%	n	%
Yes	0.36	0.02	44	81.5	10	18.5	54	100.0
No	0.28	0.00	1,338	92.9	103	7.2	1,441	100.0
Not stated	0.23	0.01	78	97.5	2	2.5	80	100.0

Educational attainment

The highest educational attainment of any adult member of the household was used as the basis for this comparison. Unfortunately, the response card did not distinguish clearly among respondents with no post-school educational qualifications, respondents who did not answer the question, and respondents with educational qualifications other than degrees, trade qualifications or apprenticeship, and certificate or diploma. The comparison is therefore limited to those responses where the kind of qualification is clear.

Mean blood lead level is 0.25 µmol/L when there is an adult with a university degree, 0.26 µmol/L when there is a trade qualification or apprenticeship, and 0.29 µmol/L when there is a certificate or diploma (Table 14).

Table 14: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by highest educational attainment in household

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Level of education	Mean	se	n	%	n	%	n	%
Bachelor's degree or higher	0.25	0.01	326	94.2	20	5.8	346	100.0
Trade qualification or apprenticeship	0.26	0.01	400	95.5	19	4.5	419	100.0
Certificate or diploma	0.29	0.01	294	90.7	30	9.3	324	100.0
Other higher education	0.34	0.04	12	92.3	1	7.7	13	100.0
No higher education or no response	0.30	0.01	428	90.5	45	9.5	473	100.0

(a) Each child in a household is counted separately.

Income

Participants were asked to indicate the range of income of each adult member of the household. The highest income range of any adult member of the household has been used as the basis for this comparison (Table 15).

Blood lead level is higher in households where the highest income is below $20,000 than in those where it is above $20,000 per year; there is only a slight gradient of blood lead with income within each of these groups of households.

Table 15: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by annual income of highest earner in household

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Annual income	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
≤$12,000	0.32	0.01	118	85.5	20	14.5	138	100.0
$12,001–$20,000	0.34	0.01	213	85.9	35	14.1	248	100.0
$20,001–$30,000	0.26	0.01	339	96.0	14	4.0	353	100.0
$30,001–$40,000	0.26	0.01	328	92.9	25	7.1	353	100.0
$40,001–$50,000	0.25	0.01	176	94.6	10	5.4	186	100.0
>$50,000	0.24	0.01	202	97.1	6	2.9	208	100.0
Not stated	0.27	0.01	84	94.4	5	5.6	89	100.0

(a) Each child in a household is counted separately.

Home ownership

Lead levels are higher in children who are residents of rented dwellings than in those resident in dwellings that are owned or being purchased (Table 16).

Table 16: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by nature of occupancy

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Home ownership	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Being paid off	0.26	0.00	747	94.9	40	5.1	787	100.0
Owned outright	0.25	0.01	263	95.6	12	4.4	275	100.0
Rented	0.32	0.01	441	87.7	62	12.3	503	100.0
Occupied rent-free	0.21	0.04	9	90.0	1	10.0	10	100.0

(a) Each child in a household is counted separately.

Car ownership

In studying car ownership, it is insufficient to examine simply the number of vehicles owned by the household which use leaded petrol. A family with no vehicles at all has no vehicles which use leaded petrol, but neither does a family with two late-model vehicles; these families are likely to have very different social circumstances. Data are therefore shown by each combination of number of vehicles using leaded petrol and number of vehicles using unleaded petrol (Table 17).

When numbers of both kinds of vehicle are shown, the lowest mean is for households with at least two vehicles using leaded petrol and at least two using unleaded petrol, so that these households had at least four vehicles. The highest mean is with no vehicles and with one vehicle using leaded petrol. In single-vehicle households the mean blood lead level is higher where the vehicle uses leaded petrol (0.32 µmol/L) than when it uses unleaded petrol (0.26 µmol/L). In households with two or more vehicles the mean level is higher when all vehicles use leaded petrol (0.31 µmol/L) than when there is one of each kind (0.25 µmol/L), or than when all vehicles use unleaded petrol (0.24 µmol/L).

Table 17: Mean and standard error (se) of blood lead level and number of children[(a)] by number of household vehicles using unleaded petrol and by number of household vehicles using leaded petrol

	Vehicles using unleaded petrol								
	None			One			Two or more		
Vehicles using leaded petrol	Mean	se	n	Mean	se	n	Mean	se	n
None	0.32	0.02	76	0.26	0.01	238	0.24	0.01	314
One	0.32	0.01	267	0.25	0.01	313	0.30	0.02	39
Two or more	0.31	0.01	256	0.26	0.02	49	0.19	0.01	23

(a) Each child in a household is counted separately.

Smoking

The presence of someone in the household who smokes inside the home has a strong relationship with blood lead level (Table 18). Results of testing lead content in cigarettes and some related calculations are at the end of this section of the report.

Table 18: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by whether there were any smokers in the household who smoke in the home

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Smoker(s) in household	Mean	se	n	%	n	%	n	%
Yes	0.33	0.01	426	87.1	63	12.9	489	100.0
No	0.25	0.00	1,032	95.2	52	4.8	1,084	100.0
Not stated	0.22	0.03	2	100.0	0	0.0	2	100.0

(a) Each child in a household is counted separately.

Physical and environmental factors relating to the household

Residence on major road

Interviewers were asked to assess whether the residence was within 25 metres of a major road, defined as a road carrying 5,000 or more vehicles per day. If in doubt, they were to indicate 'Yes'. Where they indicated 'Yes' they were also asked to name the main road or roads.

There were 333 roads assessed as main roads of which the State Main Roads Authorities were able to supply traffic counts for 279. There were 208 children who had blood taken and who were recorded as living near a main road. Of these, 57 lived near a road with an average daily traffic count of less than 5,000 vehicles and were thus reclassified as not living near a major road. For another 41 children from whom blood was collected, no traffic count was available; as counts are more likely to be available for major roads, it is likely that most of these children did not live on roads carrying more than 5,000 vehicles per day.

Lead levels are higher where the residence is within 25 metres of a major road with a traffic count of more than 5,000 vehicles per day (Table 19).

Table 19: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by location of dwelling

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Location of dwelling	Mean	se	n	%	n	%	n	%
Near major road[b]	0.29	0.02	98	89.1	12	10.9	110	100.0
Other	0.27	0.00	1,324	93.0	100	7.0	1,424	100.0
No traffic count	0.30	0.02	38	92.7	3	7.3	41	100.0

(a) Each child in a household is counted separately.

(b) Within 25 metres of a road with a mean daily traffic count of at least 5,000 vehicles.

Ownership of dogs and cats

Presence of dogs is associated with a slightly higher mean blood lead level. The difference is small. Presence of cats does not seem to affect blood lead level (Table 20).

Table 20: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by presence of dog or cat in household

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Presence of dog or cat	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Neither	0.27	0.01	626	93.2	46	6.9	672	100.0
Cat only	0.27	0.01	238	93.0	18	7.0	256	100.0
Dog only	0.29	0.01	390	91.1	38	8.9	428	100.0
Cat and dog	0.30	0.01	206	94.1	13	5.9	219	100.0

(a) Each child in a household is counted separately.

Vegetable garden

There does not appear to be any association between the blood lead level and having a vegetable garden (Table 21).

Table 21: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by presence of vegetable garden

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Vegetable garden	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Yes	0.27	0.01	484	92.7	38	7.3	522	100.0
No	0.28	0.00	976	92.7	77	7.3	1,053	100.0

(a) Each child in a household is counted separately.

Occupations and hobbies involving exposure to lead

The highest mean blood lead level of 0.36 µmol/L is found in homes where someone works in lead smelting (Table 22), but the numbers are small—the children are from nine households in eight different census districts, spread across four States. None of these households is in Broken Hill.

Two other occupations may also be associated with high lead levels. They are automotive repair (mean 0.31 µmol/L) and panel beating (mean 0.34 µmol/L).

Table 22: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, where member of household worked in occupation with exposure to lead

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Occupational exposure to lead	Mean	se	n	%	n	%	n	%
Building trades	0.28	0.01	237	94.4	14	5.6	251	100.0
Any work in scrap metal industry	0.25	0.02	49	96.1	2	3.9	51	100.0
Any work involving removal of paint	0.28	0.01	66	95.7	3	4.4	69	100.0
Road construction or maintenance	0.26	0.02	37	94.9	2	5.1	39	100.0
Any work with batteries	0.27	0.02	58	95.1	3	4.9	61	100.0
Lead smelting	0.36	0.04	11	84.6	2	15.4	13	100.0
Lead mining	0.23	0.01	3	100.0	0	0.0	3	100.0
Any work with brass	0.28	0.02	31	93.9	2	6.1	33	100.0
Any work using solder	0.26	0.01	140	96.6	5	3.5	145	100.0
Manufacture of glass	0.27	0.03	7	100.0	0	0.0	7	100.0
Automotive repair	0.31	0.02	123	91.8	11	8.2	134	100.0
Panel beating	0.34	0.03	36	87.8	5	12.2	41	100.0
Any of the above	0.28	0.01	475	93.3	34	6.7	509	100.0
None of the above	0.27	0.00	984	92.4	81	7.6	1,065	100.0
Not stated	0.43		1		0		1	100.0

(a) Each child in a household is counted separately.

The findings for hobby exposure in respect of automotive repairs and panel beating are similar to those for occupational exposure (Table 23).

Hobbies relating to ceramics, china and glass also seem to be associated with higher blood lead levels.

Table 23: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by whether member of household had hobbies involving exposure to lead

Hobbies involving exposure to lead	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
	Mean	se	n	%	n	%	n	%
Home renovation involving removal of old paint	0.29	0.01	282	92.5	23	7.5	305	100.0
Making pottery or ceramics	0.31	0.02	44	88.0	6	12.0	50	100.0
Painting china	0.41	0.17	3	60.0	2	40.0	5	100.0
Staining glass	0.36	0.04	23	79.3	6	20.7	29	100.0
Playing games with lead models	0.22	0.03	10	100.0	0	0.0	10	100.0
Making sinkers for fishing	0.33	0.03	54	85.7	9	14.3	63	100.0
Shooting	0.32	0.02	84	89.4	10	10.6	94	100.0
Panel beating or spray painting of cars	0.31	0.02	90	88.2	12	11.8	102	100.0
Automotive repairs	0.30	0.01	261	89.4	31	10.6	292	100.0
Any of the above	0.30	0.01	568	89.9	64	10.1	632	100.0
None of the above	0.26	0.00	889	94.6	51	5.4	940	100.0
Not stated	0.26	0.06	3		0		3	100.0

(a) Each child in a household is counted separately.

Year of construction of house

The year of construction of the house was estimated by the interviewer at the first visit and by the residents at the final visit. In this comparison, the residents' estimate has been used.

The older the house the higher the blood lead level (Table 24). The mean level is particularly high in homes built in 1920 or earlier. The relationship between age of home and condition of paint is shown in more detail in the next section.

Table 24: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by estimated year of construction of house

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Year of construction	Mean	se	n	%	n	%	n	%
To 1920	0.38	0.02	96	82.1	21	18.0	117	100.0
1921–1950	0.30	0.01	210	90.9	21	9.1	231	100.0
1951–1965	0.30	0.01	194	91.9	17	8.1	211	100.0
1966–1980	0.27	0.01	341	91.9	30	8.1	371	100.0
From 1981	0.24	0.00	575	96.6	20	3.4	595	100.0
Not stated	0.30	0.02	44	88.0	6	12.0	50	100.0

(a) Each child in a household is counted separately.

Condition of paintwork

The blood lead level of the child shows a strong association with the condition of internal paintwork of the residence (Table 25). The mean value is particularly high where there is severe chalking or peeling. The relationship with condition of the external paintwork is not as strong (Table 26).

Table 25: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by condition of internal paintwork

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Internal paintwork	Mean	se	n	%	n	%	n	%
Severe chalking and/or peeling	0.38	0.03	47	82.5	10	17.5	57	100.0
Some chalking and/or peeling	0.30	0.01	382	90.7	39	9.3	421	100.0
No chalking and/or peeling	0.26	0.00	992	94.1	62	5.9	1,054	100.0
No internal paintwork	0.29	0.03	31	93.9	2	6.1	33	100.0
Not stated	0.31	0.05	8	80.0	2	20.0	10	100.0

(a) Each child in a household is counted separately.

Table 26: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by condition of external paintwork

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
External paintwork	Mean	se	n	%	n	%	n	%
Severe chalking and/or peeling	0.31	0.01	88	92.6	7	7.4	95	100.0
Some chalking and/or peeling	0.29	0.01	408	91.7	37	8.3	445	100.0
No chalking and/or peeling	0.27	0.00	791	93.4	56	6.6	847	100.0
No external paintwork	0.28	0.01	171	92.9	13	7.1	184	100.0
Not stated	0.47	0.10	2	50.0	2	50.0	4	100.0

(a) Each child in a household is counted separately.

When the relationship between condition of paintwork and blood lead level is shown restricted to homes built before 1966, which may have lead in the paint, the association found previously for internal paintwork persists, although blood lead levels are higher (Table 27). There is no clear association with external paintwork (Table 28).

Table 27: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by condition of internal paintwork for homes built before 1966

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Internal paintwork	Mean	se	n	%	n	%	n	%
Severe chalking and/or peeling	0.41	0.03	32	76.2	10	23.8	42	100.0
Some chalking and/or peeling	0.31	0.01	204	91.5	19	8.5	223	100.0
No chalking and/or peeling	0.31	0.01	255	90.1	28	9.9	283	100.0
No internal paintwork	0.36	0.08	4	80.0	1	20.0	5	100.0
Not stated	0.27	0.06	5	83.3	1	16.7	6	100.0

(a) Each child in a household is counted separately.

Table 28: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by condition of external paintwork in homes built before 1966

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
External paintwork	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Severe chalking and/or peeling	0.33	0.02	63	91.3	6	8.7	69	100.0
Some chalking and/or peeling	0.31	0.01	221	89.1	27	10.9	248	100.0
No chalking and/or peeling	0.32	0.01	181	90.1	20	10.0	201	100.0
No external paintwork	0.35	0.04	33	86.8	5	13.2	38	100.0
Not stated	0.43	0.13	2	66.7	1	33.3	3	100.0

(a) Each child in a household is counted separately.

Renovation

The relation between blood lead level and whether a home has been renovated allowing for whether the child was there at the time is not clear from these introductory analyses. There is a weak association between renovation and high blood lead level, but the mean level is the same whether or not the child was present during renovation (Table 29). This may be an effect of chance, as numbers in this last category are small.

These associations persist when the tables are restricted to houses built before 1966 and before 1951 (Tables 30 and 31). Older homes are more likely to have been renovated.

Table 29: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by whether present or previous house renovated in previous 12 months and whether child was living there at the time

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Whether renovated, whether child there	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Renovated, child there	0.30	0.01	259	89.3	31	10.7	290	100.0
Renovated, child not there	0.30	0.02	61	91.0	6	9.0	67	100.0
Not renovated	0.27	0.00	1,080	94.1	68	5.9	1,148	100.0
Not stated	0.30	0.02	60	85.7	10	14.3	70	100.0

Table 30: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by whether present house renovated in previous 12 months and whether child was living there at the time, for homes built before 1966

Whether renovated, whether child there	Mean	se	Blood lead level (μmol/L) < 0.49 n	%	≥ 0.49 n	%	All n	%
Renovated, child there	0.33	0.01	133	85.3	23	14.7	156	100.0
Renovated, child not there	0.32	0.03	30	93.8	2	6.3	32	100.0
Not renovated	0.31	0.01	318	91.1	31	8.9	349	100.0
Not stated	0.32	0.03	19	86.4	3	13.6	22	100.0

Table 31: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by whether present house renovated in previous 12 months and whether child was living there at the time, for homes built before 1951

Whether renovated, whether child there	Mean	se	Blood lead level (μmol/L) < 0.49 n	%	≥ 0.49 n	%	All n	%
Renovated, child there	0.35	0.02	88	83.0	18	17.0	106	100.0
Renovated, child not there	0.32	0.05	20	90.9	2	9.1	22	100.0
Not renovated	0.32	0.01	188	90.0	21	10.1	209	100.0
Not stated	0.31	0.04	10	90.9	1	9.1	11	100.0

Cleanliness of house

There was minimal difference in mean blood lead level between the homes which interviewers rated as 'Very clean' and 'Cleaner than average', and a small difference between these and those rated as 'Average'. However, mean blood lead level was high when the home was rated 'Dirtier than average' and very high when it was 'Very dirty' (Table 32).

The three children with blood lead levels ≥ 0.49 μmol/L who lived in 'Very clean' houses had all been exposed to peeling paint (see Cases 2 and 3 in Appendix 4).

Table 32: Mean and standard error (se) of blood lead level, and number and percentage of children(a) in blood lead level groups, by cleanliness of house, as rated by interviewer

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Cleanliness of house	Mean	se	n	%	n	%	n	%
Very dirty	0.48	0.05	20	58.8	14	41.2	34	100.0
Dirtier than average	0.34	0.01	130	88.4	17	11.6	147	100.0
Average	0.28	0.00	751	93.4	53	6.6	804	100.0
Cleaner than average	0.25	0.01	388	94.4	23	5.6	411	100.0
Very clean	0.24	0.01	132	97.8	3	2.2	135	100.0
Not stated	0.28	0.02	39	88.6	5	11.4	44	100.0

(a) Each child in a household is counted separately.

Environmental specimens

Findings for dust, soil, water and paint specimens from homes of a 40% random sample of households are summarised in Table 33. Specimens were tested from 511 households in which there were 605 children.

The distributions of all environmental measurements were highly skewed. Percentile values have therefore been shown. The 'top' of the distribution in the second-last row in the table is the upper extreme of the main body of values obtained, excluding outliers. Amounts and concentrations exceeding these limits cannot be explained in terms of the distributions of most of the values (Figures 4 to 7, pages 44–45).

Table 33: Percentile points, geometric means and highest values for lead in household environmental specimens

	Floor dust µg/wipe	Soil mg/kg	Water µg/L	Paint mg/kg
Number of specimens	506	492	501	131
Lowest decile	0.06	<5	0.35	187
Lowest quartile	0.13	9	0.67	952
Median	0.24	21	1.57	2,857
Geometric mean	0.25	26	1.67	3,156
Highest quartile	0.49	68	3.65	10,703
Highest decile	0.94	208	10.66	76,916
'Top' of distribution	5.86	1,820	31.40	83,553
Highest value	45.84	8,794	118.80	294,118

Dust wipes

Four-fifths (79%) of the dust samples were from a carpet or rug surface. The geometric mean for these samples is 0.24 µg/900 cm^2 compared with 0.30 µg/900 cm^2 for all other surfaces. This difference is not statistically significant ($t = 1.6$, $p = 0.11$).

The blood lead concentrations in relation to amount of lead in the standard floor wipe are presented by deciles of the latter (Table 34). While there is some gradient of blood lead in the lowest eight deciles, there is a substantial gradient in the highest two deciles.

The measured lead in dust wipes was much higher when the interviewer judged the household as 'Dirtier than average' and higher still when it was 'Very dirty' (Table 35).

Table 34: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by decile of house dust wipe reading

House dust µg/wipe	Blood lead level (µmol/L) Mean	se	< 0.49 n	< 0.49 %	≥ 0.49 n	≥ 0.49 %	All n	All %
≤0.05	0.22	0.01	58	96.7	2	3.3	60	100.0
0.06–0.10	0.24	0.01	56	100.0	0	0.0	56	100.0
0.11–0.14	0.28	0.02	55	93.2	4	6.8	59	100.0
0.15–0.18	0.26	0.02	51	92.7	4	7.3	55	100.0
0.19–0.23	0.24	0.01	66	98.5	1	1.5	67	100.0
0.24–0.31	0.27	0.01	60	98.4	1	1.6	61	100.0
0.32–0.42	0.31	0.02	56	88.9	7	11.1	63	100.0
0.43–0.58	0.26	0.02	56	96.6	2	3.5	58	100.0
0.59–0.93	0.34	0.03	49	83.1	10	17.0	59	100.0
≥0.94	0.43	0.04	45	72.6	17	27.4	62	100.0
No dust reading	0.24	0.05	5	100.0	0	0.0	5	100.0

(a) Each child in a household is counted separately.

Table 35: Geometric means and 95% confidence intervals (CI) for dust lead loading by cleanliness of house as judged by the interviewer

Cleanliness of house	Dust lead loading (µg/900 cm^2) Geometric mean	95% CI
Very dirty	0.54	(0.27, 1.10)
Dirtier than average	0.42	(0.31, 0.59)
Average	0.24	(0.22, 0.27)
Cleaner than average	0.24	(0.20, 0.30)
Very clean	0.20	(0.14, 0.27)
Not stated	0.25	(0.14, 0.42)

Soil

The relationship between soil lead and blood lead level is very different from that for household dust and water. The blood lead levels are similar in the two quartiles below the median, and similar in the two quartiles above the median; the major division is at the median (Table 39).

Table 36: Mean and standard error (se) of blood lead level, and number and percentage of children[(a)] in blood lead level groups, by quartile of soil reading

	Blood lead level (µmol/L)							
			< 0.49		≥ 0.49		All	
Soil mg/kg	Mean	se	n	%	n	%	n	%
≤8	0.24	0.01	136	97.1	4	2.9	140	100.0
9–20	0.25	0.01	149	97.4	4	2.6	153	100.0
21–67	0.33	0.02	132	86.3	21	13.7	153	100.0
≥68	0.32	0.02	124	88.6	16	11.4	140	100.0
No soil reading	0.31	0.04	16	84.2	3	15.8	19	100.0

(a) Each child in a household is counted separately.

Water

The current National Health and Medical Research Council standard for lead in water is that it should be less than 50 µg/L, but a draft revision proposes that the limit should become 10 µg/L. Water in three of 501 homes would not meet the current standard, and water in 54 of 501 homes (11%) would not meet the proposed standard.

We examined whether our findings could have occurred because most specimens were first-flush morning specimens, and whether daily average lead levels might be lower. Three-quarters (74%) of water samples were taken by a householder at first flush as instructed and the rest were taken at the time of interview or at some other time. The geometric mean (1.8 µg/L) for first-flush samples is higher than that for other samples (1.4 µg/L), but the difference is not statistically significant ($t = 1.8$, $p = 0.07$).

When households are divided into quartiles by lead concentration in water, the mean blood lead level is very similar in the lowest two quartiles and a little higher in the third quartile. Mean blood lead level is higher when the household is in the highest quartile for lead concentration in water (Table 36).

Numbers in all supply categories other than town or mains water are small, but there does not appear to be any general relationship between water supply and blood lead level (Table 37). No conclusions can be drawn in relation to roofing material where rainwater is a source of supply, again because of small numbers (Table 38).

Table 37: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by quartile of water reading

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Water μg/L	Mean	se	n	%	n	%	n	%
≤0.66	0.26	0.01	151	98.7	2	1.3	153	100.0
0.67–1.56	0.25	0.01	144	98.0	3	2.0	147	100.0
1.57–3.64	0.29	0.01	136	90.7	14	9.3	150	100.0
≥3.65	0.35	0.02	117	80.7	28	19.3	145	100.0
No water reading	0.32	0.04	9	90.0	1	10.0	10	100.0

(a) Each child in a household is counted separately.

Table 38: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by nature of water supply

			Blood lead level (μmol/L)					
			< 0.49		≥ 0.49		All	
Water supply	Mean	se	n	%	n	%	n	%
Mains/town water	0.27	0.00	1,185	92.9	91	7.1	1,276	100.0
Mains, rainwater tanks[b]	0.29	0.02	61	92.4	5	7.6	66	100.0
Mains, bottled water	0.30	0.02	90	90.9	9	9.1	99	100.0
Mains, other	0.21	0.02	20	95.2	1	4.8	21	100.0
Rainwater tanks	0.30	0.02	85	90.4	9	9.6	94	100.0
Rainwater tanks, any other	0.27	0.03	12	100.0	0	0.0	12	100.0
All other	0.31	0.05	7	100.0	0	0.0	7	100.0

(a) Each child in a household is counted separately.

(b) Includes two households in which bottled water was also used.

Table 39: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by roofing material for homes with rainwater tanks

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Roofing material	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Tiles	0.26	0.03	35	94.6	2	5.4	37	100.0
Metal sheeting	0.30	0.02	115	90.6	12	9.5	127	100.0
Other	0.30	0.04	8	100.0	0	0.0	8	100.0
No rainwater tanks	0.27	0.00	1,302	92.8	101	7.2	1,403	100.0

(a) Each child in a household is counted separately.

Paint

Paint specimens were collected only from the 30% of homes where paint was in poor condition. Thus the data on lead levels in paint are representative of Australian homes with deteriorating paint rather than of all Australian homes.

Mean blood lead levels were high in all quartiles of homes with deteriorating paint, when these were further divided by quartile of lead concentration in the paint. There was no difference between the lowest two quartiles of lead concentration in paint, some difference between these and the third quartile, and a greater difference between these and the highest quartile, where the mean blood lead level and the proportion of blood lead levels at or exceeding 0.49 µmol/L were both high (Table 40).

Table 40: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by quartile of paint reading

			Blood lead level (µmol/L)					
			< 0.49		≥ 0.49		All	
Paint mg/kg	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
≤951	0.30	0.03	37	92.5	3	7.5	40	100.0
952–2,856	0.30	0.04	33	91.7	3	8.3	36	100.0
2,857–10,702	0.34	0.03	33	89.2	4	10.8	37	100.0
≥10,703	0.41	0.03	29	76.3	9	23.7	38	100.0
No paint reading	0.27	0.01	425	93.6	29	6.4	454	100.0

(a) Each child in a household is counted separately.

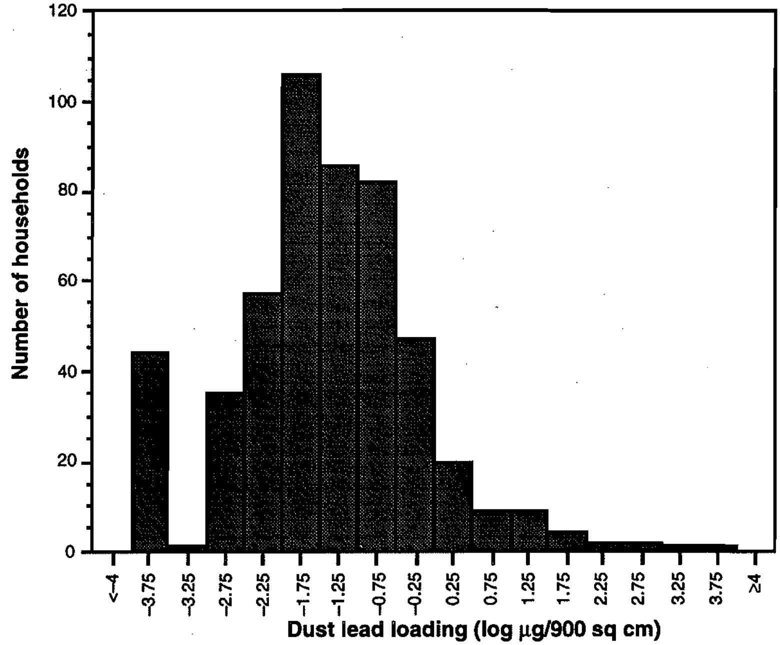


Figure 4: Distribution of log-transformed dust lead levels for a 40% random sample of households

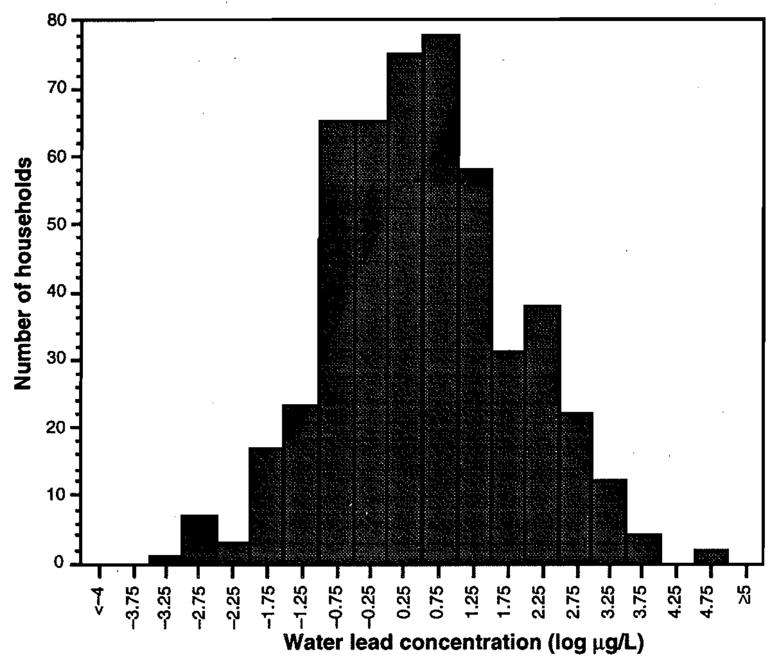


Figure 5: Distribution of log-transformed water lead levels for a 40% random sample of households

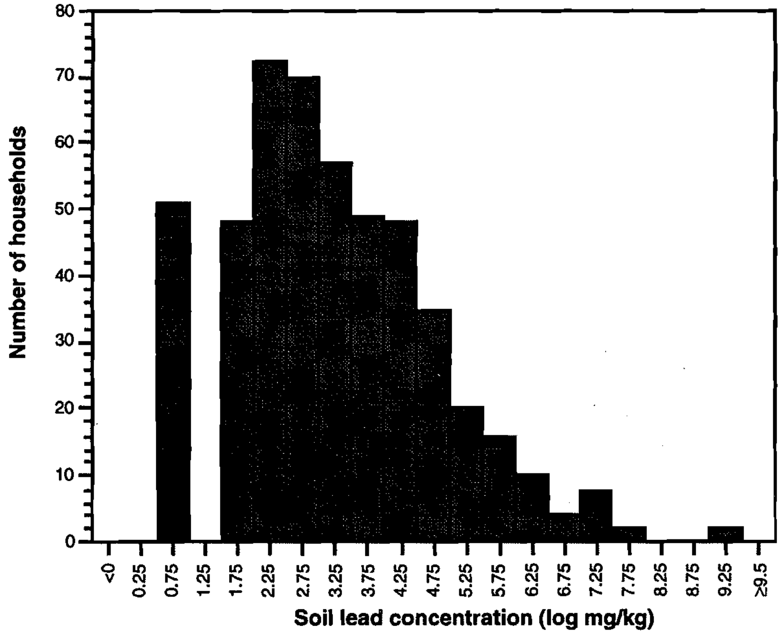


Figure 6: Distribution of log-transformed soil lead levels for a 40% random sample of households

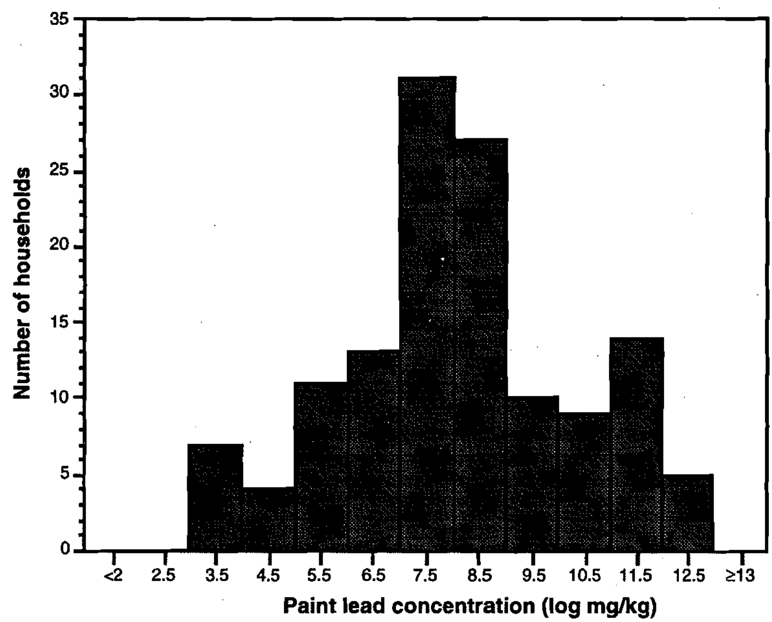


Figure 7: Distribution of log-transformed paint lead levels for a 40% random sample of households with peeling or chalking paint

Factors relating to the child

Sucking fingers or thumb and sucking or chewing toys

There are no clear associations between blood lead levels and either sucking fingers or thumb and sucking or chewing toys (Tables 41 and 42).

Table 41: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by frequency of child sucking finger or thumb

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Frequency of sucking	Mean	se	n	%	n	%	n	%
Every day	0.28	0.01	493	92.2	42	7.9	535	100.0
> once/week	0.26	0.01	135	97.8	3	2.2	138	100.0
< once/week	0.28	0.01	227	93.8	15	6.2	242	100.0
Never	0.28	0.01	604	91.7	55	8.4	659	100.0
Not stated	0.41		1	100.0	0	0.0	1	100.0

Table 42: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by frequency of child sucking or chewing toys

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Frequency of sucking or chewing	Mean	se	n	%	n	%	n	%
Every day	0.28	0.01	403	91.8	36	8.2	439	100.0
> once/week	0.29	0.01	168	90.8	17	9.2	185	100.0
< once/week	0.28	0.01	276	92.6	22	7.4	298	100.0
Never	0.27	0.01	612	93.9	40	6.1	652	100.0
Not stated	0.31		1	100.0	0	0.0	1	100.0

Eating soil

There is a strong association between eating soil and blood lead level (Table 43). The relationship persists regardless of the age of the house, although lead levels are lower overall for children living in houses built since 1966 (Tables 44 and 45).

Table 43: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by frequency of eating soil

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Frequency of eating soil	Mean	se	n	%	n	%	n	%
Every day	0.45	0.04	34	68.0	16	32.0	50	100.0
> once/week	0.33	0.02	81	91.0	8	9.0	89	100.0
< once/week	0.30	0.01	199	90.1	22	10.0	221	100.0
Never	0.26	0.00	1,144	94.3	69	5.7	1,213	100.0
Not stated	0.15	0.01	2	100.0	0	0.0	2	100.0

Table 44: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by frequency of eating soil for homes built 1966 and later

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Frequency of eating soil	Mean	se	n	%	n	%	n	%
Every day	0.39	0.04	22	73.3	8	26.7	30	100.0
> once/week	0.30	0.02	51	96.2	2	3.8	53	100.0
< once/week	0.27	0.01	129	93.5	9	6.5	138	100.0
Never	0.24	0.00	713	95.8	31	4.2	744	100.0
Not stated	0.14		1	100.0	0	0.0	1	100.0

Table 45: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by frequency of eating soil for homes built before 1966

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Frequency of eating soil	Mean	se	n	%	n	%	n	%
Every day	0.53	0.09	12	63.2	7	36.8	19	100.0
> once/week	0.37	0.04	26	81.3	6	18.8	32	100.0
< once/week	0.36	0.02	66	84.6	12	15.4	78	100.0
Never	0.30	0.01	395	92.1	34	7.9	429	100.0
Not stated	0.16		1	100.0	0	0.0	1	100.0

Child care

Mean blood lead level is higher in children who are not cared for away from home for at least half a day a week than for those who are. The interpretation of this finding is considered later. For children receiving child care, the mean blood lead level does appear to be higher when the care is in an older building with deteriorating paintwork (Table 46).

Table 46: Mean and standard error (se) of blood lead level, and number and percentage of children in blood lead level groups, by use of child care, and whether this is in an area at risk of lead from paint

	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
Child care status	**Mean**	**se**	**n**	**%**	**n**	**%**	**n**	**%**
Child care, apparent risk[(a)]	0.29	0.01	130	93.5	9	6.5	139	100.0
Child care, no apparent risk	0.26	0.01	755	95.1	39	4.9	794	100.0
No child care	0.30	0.01	568	89.5	67	10.6	635	100.0
Not stated	0.39	0.11	7	100.0	0	0.0	7	100.0

(a) Child care for at least half a day per week for one month or more, in pre-1970 building with at least some chalking and/or peeling of external or internal paint.

Regression analyses

The single-variable analyses show that blood lead concentration appears to have a complex association with a number of factors or variables. It is not sufficient to examine only the relationship between blood lead levels and each factor separately, as this may be misleading. In particular, an apparent association between blood lead level and any one factor may be due to both being associated with a second factor, an effect known as confounding.

Regression analysis is a statistical method for analysing the relationship between a particular variable of interest, in this case blood lead concentration, and a set of other variables or factors. The regression models the relationship of blood lead level with all the factors simultaneously, and 'adjusts for' or 'controls for' any confounding effects.

The regression model is expressed as an equation that estimates or 'predicts' the value of blood lead concentration from a function of the factors. Prediction in this sense means estimating blood lead level from the values of the factors, for an observation taken under the same circumstances as the sample from which the regression equation was derived. This does not imply that any of the factors actually cause changes in blood lead level. The regression only models relationships or associations between blood lead level and other factors; any inferences that such relationships are due to direct cause and effect can only be made on the basis of other knowledge.

Linear regression without environmental measures

The results of linear regression analysis of blood lead level are presented in Table 47. All of the factors considered previously were tested for inclusion as variables in the regression model. For most factors the regression model generally reflects the univariate results, but for some factors the apparent association with blood lead level disappears because the regression adjusts for other variables which may be responsible for the association.

This analysis was done both before and after adjusting blood lead level for haematocrit. This adjustment made no substantial difference to the results of the regression, so that results reported here are not adjusted for haematocrit.

The regression was carried out on the natural logarithm (abbreviated as log) of blood lead (see 'Methods' section) and the results are shown both on the log and linear scales. The intercept term in Table 47 is the estimated blood lead level of a child who is in the reference category for each variable; that is, for a child who lives in New South Wales (but not Broken Hill), is 1 year old, and who has the values of other variables indicated in the first column of Table 47. The estimated level is –1.639 with a standard error of 0.044 on the natural log scale, which converts to 0.19 µmol/L on the linear scale with a 95% confidence interval (CI) of 0.18 µmol/L to 0.21 µmol/L.

To estimate the blood lead levels of children with different sets of characteristics, the appropriate terms on the log scale are added to the intercept term and the result exponentiated. This is equivalent to successively multiplying the intercept by the corresponding terms on the linear scale.

As was found in the unadjusted results (see Table 10), other factors being equal, South Australia and the Northern Territory are still estimated to have the highest blood lead levels. This suggests that there are factors operating in these two jurisdictions that have not been covered by the survey. An apparent interaction was found between State or Territory and the age of the home which can be explained by children in South Australia who live in stone homes built before 1921 having lower lead levels than might otherwise be expected.

The two CDs in Broken Hill were the only ones in the survey near substantial lead smelting or mining activities. It was necessary to control for living in them. The mean blood lead level of the five children from Broken Hill was 0.60 µmol/L, but the range of readings was wide, from 0.36 to 0.92 µmol/L.

The relationship of blood lead level with age changes after controlling for other variables. There is no difference between 1- and 2-year-olds. After age 2 there is a decrease but it is not as steep as in the association shown in Table 12. (The predicted blood lead concentrations for children aged 1, 2, 3 and 4 years and in the reference category for all other variables are 0.194 µmol/L, 0.195 µmol/L, 0.183 µmol/L and 0.176 µmol/L respectively). This change appears to be due to the association between age and eating soil.

The associations with blood lead level of maximum educational level and maximum individual income in household remain little changed from the single-variable analysis, in that they can still be summarised by two levels of each factor. Highest family income equal to or less than $20,000 is associated with an increase in blood lead over that where incomes are higher, while tertiary education at degree level is associated with a decrease in blood lead.

Table 47: Linear regression model for blood lead concentration (based on 1,575 children)

			Regression coefficients			
			Log scale		Linear scale	
Variable	Category[(a)]	F-statistic[(b)]	Estimate	se	Estimate with 95% CI	
Intercept			–1.639	0.044	0.19	(0.18, 0.21)
State/Territory	*NSW*	3.1**				
	Vic		0.036	0.033	1.04	(0.97, 1.11)
	Qld		0.052	0.035	1.05	(0.98, 1.13)
	WA		0.081	0.040	1.08	(1.00, 1.17)
	SA		0.136	0.046	1.15	(1.05, 1.25)
	Tas		–0.027	0.045	0.97	(0.89, 1.06)
	ACT		–0.069	0.060	0.93	(0.83, 1.05)
	NT		0.233	0.100	1.26	(1.04, 1.53)
SA stone house built before 1921	*No*	9.7**				
	Yes		–0.436	0.140	0.65	(0.49, 0.85)
Broken Hill	*No*	14.8***				
	Yes		0.779	0.202	2.18	(1.47, 3.24)
Age	*1 year*	4.2**				
	2 years		0.005	0.034	1.00	(0.94, 1.07)
	3 years		–0.058	0.036	0.94	(0.88, 1.01)
	4 years		–0.098	0.037	0.91	(0.84, 0.97)
Income[(c)]	*> $20,000 pa*	17.7***				
	≤ $20,000 pa		0.117	0.028	1.12	(1.06, 1.19)
Education[(c)]	*Pre-tertiary*	10.2**				
	Tertiary		–0.092	0.029	0.91	(0.86, 0.97)
Year of house	*After 1980*	18.7***				
	1966–1980		0.067	0.030	1.07	(1.01, 1.13)
	1951–1965		0.152	0.037	1.16	(1.08, 1.25)
	1921–1950		0.175	0.036	1.19	(1.11, 1.28)
	Before 1921		0.439	0.048	1.55	(1.41, 1.71)
	Unknown		0.102	0.067	1.11	(0.97, 1.26)
Cleanliness of house	*Average*	7.9***				
	Very dirty		0.346	0.078	1.41	(1.21, 1.65)
	Dirtier than average		0.105	0.040	1.11	(1.03, 1.20)
	Cleaner than average		–0.073	0.027	0.93	(0.88, 0.98)
	Very clean		–0.082	0.042	0.92	(0.85, 1.00)
	Not recorded		–0.038	0.070	0.96	(0.84, 1.10)

(continued)

Table 47: Linear regression model for blood lead concentration (based on 1,575 children) (continued)

			Regression coefficients			
			Log scale		Linear scale	
Variable	Category[a]	F-statistic[b]	Estimate	se	Estimate with 95% CI	
Interior paint chalking/peeling[d]	*Not severe*	4.8*				
	Severe		0.116	0.053	1.12	(1.01, 1.25)
Smoker in household	*No*	23.2***				
	Yes		0.128	0.027	1.14	(1.08, 1.20)
Leaded petrol vehicles	*None*	8.3**				
	One or more		0.067	0.023	1.07	(1.02, 1.12)
Eats soil	*Never*	10.4***				
	< once per week		0.080	0.035	1.08	(1.01, 1.16)
	> once per week		0.162	0.052	1.18	(1.06, 1.30)
	Every day		0.327	0.067	1.39	(1.22, 1.58)
Lead smelting[e]	*No*	6.7*				
	Yes		0.326	0.126	1.39	(1.08, 1.77)
Panel beating[e]	*Not both hobby and occupation*	7.3**				
	Both occupation and hobby		0.238	0.088	1.27	(1.07, 1.51)
Scrap metal or solder occupation[f]	*No*	7.7**				
	Yes		–0.102	0.037	0.90	(0.84, 0.97)
Hobbies[g]	*None*	6.4*				
	One or more		0.060	0.024	1.06	(1.01, 1.11)

(a) An italic entry indicates the reference category.

(b) F-Statistic is $F_{n-1,\ 1540}$ where n is the number of categories for the variable.
Statistical significance of F is indicated as *** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$. $R^2 = 0.25$.

(c) Highest level of any individual household member.

(d) Present house or previous house in which child lived for at least three out of the previous six months.

(e) Any involvement by a member of the household.

(f) Occupation of anyone in household involves any work in scrap metal industry or any work using solder.

(g) Includes nine hobbies practised by anyone in household which involve possible exposure to lead (see Table 23).

Although there are relationships between income and several variables relating to the household, the effect of income seen in the single-variable analyses mostly remains after controlling for year house was built, condition of paintwork, smoker in household, occupation, and ownership of leaded petrol vehicles.

The difference in mean blood lead between Aboriginal and Torres Strait Islander children and other children (previously noted in Table 13) is no longer statistically significant after adjustment for other variables in the regression model ($F_{1,1540} = 3.4$, $p = 0.07$). The predicted blood lead concentrations for Aboriginal and non-Aboriginal children in the reference category for all other variables are 0.219 and 0.194 µmol/L respectively.

Location near a major road is not statistically significant whether adjusted or unadjusted for other variables, and there is no gradient of blood lead with increasing traffic count. The slightly higher mean blood level in children living on a main road (Table 19) may be explained by their higher likelihood of living in low-income households or in older homes. Of the children who live near a major road and for whom the age of house is known, 56% live in a home built before 1951, compared with 20% of children who do not live near a major road.

The association between renting and blood lead level found before, but not after, adjustment for other variables (see Table 16) may be a result of low-income earners being more likely to rent, of rented homes being more likely to have peeling paint, or of both. Of renters, 47% are low-income earners compared with 16% of non-renters. Of rented homes, 44% have chalking or peeling paint compared with 24% of all other homes.

The presence of a smoker in the household and the ownership of one or more vehicles using leaded petrol remain as statistically significant covariates after adjusting for income, education and other variables.

The univariate tables showed that there were gradients in blood lead level with age of house, cleanliness of house and frequency of eating soil. These three associations are also the strongest in the linear regression after controlling for other variables. In particular, houses built before 1921, houses judged by the interviewer to be very dirty, and eating soil every day are strongly associated with high blood lead.

The inverse association between mean blood lead level and use of child care (see Table 46) is possibly due to the relationship of this variable with age of child. Older children are more likely to be in child care than younger children.

In single-variable analyses (Tables 25 to 28), condition of paintwork was statistically significantly related to blood lead only for interior paint which showed severe chalking or peeling. The last relationship is not nearly as strong after controlling for age and cleanliness of house, and there is no evidence of the gradient with condition of paintwork seen in Table 25. The condition of exterior paintwork is correlated to a certain extent with that of interior paintwork, and any association between exterior paintwork and blood lead disappears after controlling for interior paintwork.

Renovation of the present or previous house involving removal of paint did not have a statistically significant relationship with blood lead level. The small difference between the mean blood lead of children in renovated and unrenovated houses (Table 29) seems to be due to the fact that renovation is more likely in older houses. Although renovation may be an important cause of elevated blood lead in a small number of individual children (see Case 3 in Appendix 4), in general this does not seem to be the case.

Several occupations of household members are statistically significantly associated with blood lead level of children. As might be expected, lead smelting is associated with an increase in blood lead level, although there were only thirteen children in nine households affected. Only two households, one in Goulburn and one in Newcastle, had persons engaged in lead mining, so it is unlikely that any relationship would be found between this activity and blood lead.

Two occupations were associated with low blood lead level. These were any work in the scrap metal industry and any work using solder. They have been combined into one term in the regression model (Table 47). No explanation is apparent.

Panel beating had a statistically significant association with blood lead when practised by a household member as an occupation but not as a hobby. However, the strongest association was apparent for children in households in which it is practised as both an occupation and a hobby. This may signify those households where a substantial amount of panel beating is carried on at the home. The mean blood lead for children in such households is 0.37 μmol/L (Table 48).

Table 48: Mean and standard error (se) of blood lead level, and number and percentage of children[a] in blood lead level groups, by household member having panel beating as occupation and/or hobby

Panel beating as occupation or hobby	Blood lead level (μmol/L)							
			< 0.49		≥ 0.49		All	
	Mean	se	n	%	n	%	n	%
Neither	0.27	0.00	1,353	93.0	102	7.0	1,455	100.0
Occupation only	0.29	0.03	13	92.9	1	7.1	14	100.0
Hobby only	0.29	0.02	67	89.3	8	10.7	75	100.0
Both	0.37	0.04	23	85.2	4	14.8	27	100.0

(a) Each child in a household is counted separately.

There is no statistically significant association between any one hobby involving possible exposure to lead and blood lead level, possibly because many hobbies are practised by only a few household members of survey children. However, there is an apparent overall effect which is statistically significant, with the practice of one or more listed hobbies in the household being associated with higher levels of blood lead.

No other variables measured by way of the Questionnaire had statistically significant associations with blood lead level in this regression model.

Interactions in linear regression model

There were four statistically significant interactions between variables in the regression model, besides the interaction between State and age of house (represented by the term for South Australian stone houses built before 1921). These interactions were between State and cleanliness of house ($F_{32,1540} = 1.5$, $p < 0.05$), State and level of income ($F_{7,1540} = 2.4$, $p < 0.05$), level of education and smoker in household ($F_{1,1540} = 4.0$, $p < 0.05$), and smoker in household and frequency of eating soil ($F_{1,1540} = 6.1$, $p < 0.05$).

None of these appears to be meaningful as they would not be expected on the basis of any prior knowledge. Because of the large number of possible interactions a few chance interactions are likely to be statistically significant at the 5% level. Further, the addition of any of these interaction terms does not substantially change the parameter estimates for any other covariates. A model without any interaction terms appears to be the most meaningful.

Linear regression with environmental measures

Samples of dust, water, soil and, where it was deteriorating, paint were sought from all households and obtained from the great majority (see Tables 4 to 6). All samples from households where any child had a blood lead level greater than or equal to 0.49 µmol/L and all other samples from South Australia, Tasmania, the Australian Capital Territory and the Northern Territory were analysed, but only a 40% systematic random sample from households in the other four States where no child had a blood lead level greater than or equal to 0.49 µmol/L was analysed.

The linear regression analysis in this section uses the maximum data set of children from households where dust, water and soil were all collected. The data set includes all such households from the four smaller States and Territories (304 children from South Australia, Tasmania, the Australian Capital Territory and the Northern Territory) and all such households in the 40% systematic random sample from the other four States (453 children). It includes 48% of all children with lead measurements.

Table 49: Linear regression model including environmental results for blood lead concentration for all children from South Australia, Tasmania, the Australian Capital Territory and the Northern Territory, and a systematic random sample of children from New South Wales, Victoria, Queensland and Western Australia (based on 757 children)

			Regression coefficients			
			Log scale		Linear scale	
Variable	Category[a]	F-statistic[b]	Estimate	se	Estimate with 95% CI	
Intercept			–1.528	0.081	0.22	(0.19, 0.25)
Dust lead loading	log µg/900 cm^2	40.9***	0.093	0.015	1.10	(1.07, 1.13)
Water lead concentration	log µg/L	10.1***	0.038	0.012	1.04	(1.01, 1.06)
Soil lead concentration	log mg/kg	11.2**	0.038	0.012	1.04	(1.01, 1.06)
State/Territory	*NSW*	2.5*				
	Vic		0.104	0.054	1.11	(1.00, 1.23)
	Qld		0.106	0.058	1.11	(0.99, 1.25)
	WA		0.088	0.068	1.09	(0.96, 1.25)
	SA		0.081	0.058	1.08	(0.97, 1.21)
	Tas		–0.008	0.057	0.99	(0.89, 1.11)
	ACT		–0.113	0.073	0.89	(0.77, 1.03)
	NT		0.196	0.114	1.22	(0.97, 1.52)
Broken Hill	*No*	13.9***				
	Yes		1.213	0.325	3.36	(1.78, 6.36)
Age	*1 year*	3.0*				
	2 years		–0.064	0.048	0.94	(0.85, 1.03)

(continued)

Table 49: Linear regression model including environmental results for blood lead concentration for all children from South Australia, Tasmania, the Australian Capital Territory and the Northern Territory, and a systematic random sample of children from New South Wales, Victoria, Queensland and Western Australia (based on 757 children) (continued)

			Regression coefficients			
			Log scale		Linear scale	
Variable	Category[a]	F-statistic[b]	Estimate	se	Estimate with 95% CI	
	3 years		–0.120	0.052	0.89	(0.80, 0.98)
	4 years		–0.151	0.054	0.86	(0.77, 0.96)
Income[c]	*> $20,000 pa*	14.6***				
	≤ $20,000 pa		0.157	0.041	1.17	(1.08, 1.27)
Education[c]	*Pre-tertiary*	6.0*				
	Tertiary		–0.103	0.042	0.90	(0.83, 0.98)
Cleanliness of house	*Average*	3.2**				
	Very dirty		0.200	0.108	1.22	(0.99, 1.51)
	Dirtier than average		0.060	0.060	1.06	(0.94, 1.19)
	Cleaner than average		–0.101	0.040	0.90	(0.83, 0.98)
	Very clean		–0.122	0.061	0.89	(0.78, 1.00)
	Not recorded		–0.135	0.111	0.87	(0.70, 1.09)
Smoker in household	*No*	7.7**				
	Yes		0.111	0.040	1.12	(1.03, 1.21)
Leaded petrol vehicles	*None*	9.7**				
	One or more		0.107	0.034	1.11	(1.04, 1.19)
Eats soil	*Never*	5.8***				
	< once per week		0.080	0.050	1.08	(0.98, 1.20)
	> once per week		0.180	0.079	1.20	(1.03, 1.40)
	Every day		0.336	0.090	1.40	(1.17, 1.67)
Lead smelting[d]	*No*	8.9**				
	Yes		0.529	0.177	1.70	(1.20, 2.40)
Scrap metal or solder occupation[e]	*No*	4.2*				
	Yes		–0.114	0.056	0.89	(0.80, 1.00)
Hobbies[f]	*None*	8.2**				
	One or more		0.097	0.034	1.10	(1.03, 1.18)

(a) An italic entry indicates the reference category.

(b) F-statistic is $F_{n-1,727}$ where n is the number of categories for the variable.
Statistical significance of F is indicated as *** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$. $R^2 = 0.31$.

(c) Highest level of any individual household member.

(d) Any involvement by a member of the household.

(e) Occupation of anyone in household involves any work in scrap metal industry or any work using solder.

(f) Includes nine hobbies practised by anyone in household which involve possible exposure to lead (see Table 23).

Dust lead loading, water lead concentration and soil lead concentration were all transformed to natural logarithms because of their highly skewed distributions. The results of the regression are shown in Table 49. All three environmental measures are positively and statistically significantly associated with blood lead level, with dust lead loading clearly having the strongest such association.

In this regression, as well as reflecting actual differences between States and Territories, the State term also controls for any effects of taking varying proportions from the two State and Territory groups. Even so, the parameter estimates for each of the States and Territories do not differ substantially from the previous regression model, and are generally well within its 95% confidence limits.

The other variables which have statistically significant associations with lead level in the current model show substantially the same patterns as in the previous linear regression model. These are age, residence in Broken Hill, income, education, cleanliness of house, presence of smoker in household, ownership of leaded petrol vehicles, frequency of eating soil, lead smelting as an occupation, occupations involving scrap metal or solder, and the practice of one or more at-risk hobbies.

There were only 218 children who had readings for paint lead concentration, and for these children there is a statistically significant association with blood lead level ($F_{1,216} = 9.1$, $p < 0.01$) . However, this association is no longer statistically significant after controlling for other variables, most notably dust lead loading ($F_{1,192} = 0.8$, $p > 0.05$).

There were 33 children whose current or recent previous household had severe chalking or peeling of internal paintwork. The condition of interior paintwork is correlated with a number of variables including dust lead loading, income, cleanliness of house and smoker in household, and its association with blood lead level is no longer apparent after adjusting for these variables. In particular, the geometric mean for dust lead loading is 0.56 $\mu g/900\ cm^2$ for current households with severely chalking or peeling interior paintwork but only 0.24 $\mu g/900\ cm^2$ for other current households (t-test for difference = 3.7, $p = 0.001$).

There is some indication that the variation in blood lead levels with age and with cleanliness of house is affected by controlling for the three environmental measures. In this model there is possibly greater variation with age, but the parameter estimates in the present model are within the 95% confidence interval of the previous linear regression. There is less variation with cleanliness of house. This may have occurred because cleanliness of house and the dust reading are highly correlated (Table 35).

Year of construction of house no longer shows a statistically significant association with blood lead. This is mainly due to its being strongly correlated with both dust lead loading and soil lead concentration (Table 50). Thus, in the previous analysis, the association between blood lead level and year of construction probably reflects the amount of lead in and around the house.

Table 50: Geometric means and 95% confidence intervals (CI) for dust lead loading and soil lead concentration by year of construction of house

	Dust lead loading (µg/900 cm^2)		Soil lead concentration (mg/kg)	
Year of construction	**Geometric mean**	**95% CI**	**Geometric mean**	**95% CI**
To 1920	0.62	(0.44, 0.86)	177.5	(117.6, 267.7)
1921–1950	0.40	(0.32, 0.51)	96.9	(75.9, 123.7)
1951–1965	0.29	(0.23, 0.35)	35.5	(27.6, 45.7)
1966–1980	0.25	(0.21, 0.29)	20.4	(16.9, 24.6)
From 1981	0.18	(0.16, 0.21)	8.9	(8.0, 9.8)
Not stated	0.22	(0.15, 0.31)	54.7	(36.6, 81.8)

In this regression there is no statistically significant association of panel beating with blood lead level. This appears to be not just as a result of small numbers, but because there is a correlation of this variable with dust lead loading. There were 13 children for whom a household member practised panel beating as both a hobby and an occupation. The geometric mean for dust lead loading for these children's homes was 0.64 µg/900 cm^2 compared with 0.25 µg/900 cm^2 for all other homes (t-test for difference = 2.9, $p = 0.004$). This supports the suggestion that extensive panel beating at home does increase the lead level in the domestic environment.

There are statistically significant interactions between dust loading and both water concentration ($F_{1,390} = 6.5$, $p < 0.05$) and soil concentration ($F_{1,390} = 4.0$, $p < 0.05$). It is thus possible that the combined effect on blood lead of lead levels in dust and in either water or soil is greater than would be predicted from adding the individual estimates for each pair.

None of the interactions which were statistically significant in the previous linear regression was statistically significant in this model. Three interactions between the environmental measures and other variables were statistically significant. One is between soil lead concentration and smoker in household ($F_{1,726} = 7.9$, $p < 0.01$), and is unlikely to be meaningful. Another is between soil lead concentration and cleanliness of house ($F_{5,722} = 2.2$, $p < 0.05$). This could be interpreted as suggesting that the effect of not keeping the house clean is greater where soil lead levels are high than where they are low.

The third new interaction is between dust lead loading and age ($F_{3,724} = 2.9$, $p < 0.05$). Blood lead level in a child of 1 year, which puts its hands on the floor much more often than a child of 4 years, is much more likely to be affected by a dirty floor. The correlation between blood lead concentration and dust lead loading is thus higher for 1- and 2-year-olds ($r = 0.33$ and 0.35 respectively) than for 3- and 4-year-olds ($r = 0.29$ and 0.18 respectively).

Logistic regression without environmental measures

Logistic regression is a commonly used statistical model in epidemiological studies. It is analogous to linear regression, but instead of assessing the association of factors with blood lead level itself, it models the association with the likelihood of the blood lead level being equal to or greater than 0.49 µmol/L. Whereas the linear regression model can be thought of as assessing the possible influence of a variable on the geometric mean blood lead, the logistic regression assesses its possible influence on the probability of high values. As for linear regression, the main purpose of logistic regression is to determine the relative importance of the various factors while controlling for confounding.

By simplifying the measurement of blood lead in this way, some information is lost so that some associations may no longer be shown to be statistically significant. However, those variables which are strongly associated with the likelihood of having a more extreme blood lead level should remain statistically significant.

The three variables in the linear regression model which are associated with the greatest differences in blood lead level are also those for which the effects in this analysis are strongest (Table 51). Living in a house built prior to 1921, living in a house judged as very dirty and eating soil every day have the highest odds ratios (approximately 7, 5 and 4 respectively).

Low income, the presence of a smoker in the household, and one or more at-risk hobbies in the household all have odds ratios of around 2. Thus these variables are also associated with an increased likelihood of a child having a blood lead level of 0.49 µmol/L or greater, more so than might be expected from the results of the linear regression. In contrast, none of State, level of education, condition of interior paint, presence of leaded petrol vehicles and occupation has a statistically significant odds ratio and so these variables are apparently not associated with an increased chance of a high blood lead value.

Age exhibits a different pattern of association in the logistic model from that in the linear regression. The highest odds ratio relative to age 1 (1.31) is for age 2, and age 4 has a particularly low odds ratio (0.36). It appears that after controlling for other variables, 1- and 2-year-olds have similar mean values, but the blood lead level of a 2-year-old is still more likely to be 0.49 µmol/L or greater. Similarly, the mean level for 3-year-olds is only slightly higher than that for 4-year-olds, but a 3-year-old is much more likely to have a high blood lead level.

Table 51: Logistic regression model for blood lead level being equal to or greater than 0.49 μmol/L (based on 1,575 children)

Variable	Category[(a)]	Chi-square statistic[(b)]	Log odds ratio		Odds ratio	
			Estimate	se	Estimate with 95% CI	
Intercept			–4.26	0.40	0.01	(0.01, 0.03)
SA stone house built before 1921	*No*	5.9*				
	Yes		–6.39	7.33	–[(c)]	
Age	*1 year*	13.8**				
	2 years		0.27	0.28	1.31	(0.75, 2.29)
	3 years		–0.19	0.33	0.82	(0.43, 1.56)
	4 years		–1.01	0.42	0.36	(0.16, 0.82)
Highest income[(d)]	*> $20,000 pa*	14.9***				
	≤ $20,000 pa		0.89	0.23	2.43	(1.56, 3.78)
Year of house	*After 1980*	27.2***				
	1966–1980		0.75	0.31	2.12	(1.15, 3.93)
	1951–1965		0.49	0.37	1.63	(0.79, 3.34)
	1921–1950		0.73	0.35	2.08	(1.05, 4.12)
	Before 1921		1.91	0.36	6.77	(3.34, 13.8)
	Unknown		0.72	0.57	2.06	(0.68, 6.29)
Cleanliness of house	*Average*	16.6**				
	Very dirty		1.69	0.44	5.44	(2.30, 12.9)
	Dirtier than average		0.24	0.32	1.27	(0.68, 2.37)
	Cleaner than average		0.00	0.27	1.00	(0.59, 1.71)
	Very clean		–0.57	0.62	0.57	(0.17, 1.90)
	Not recorded		0.73	0.54	2.08	(0.72, 6.03)
Smoker in household	*No*	10.8**				
	Yes		0.75	0.23	2.11	(1.35, 3.29)
Eats soil	*Never*	12.7**				
	< once per week		0.45	0.29	1.57	(0.89, 2.76)
	> once per week		0.34	0.44	1.40	(0.59, 3.34)
	Every day		1.44	0.40	4.24	(1.95, 9.20)
Hobbies[(e)]	*None*	8.7**				
	One or more		0.63	0.22	1.88	(1.23, 2.87)

(a) An italic entry indicates the reference category.

(b) Likelihood ratio chi-square with n–1 degrees of freedom, where n is the number of categories for the variable. Statistical significance of chi-square is indicated as *** p < 0.001, ** 0.001 < p < 0.01, * 0.01 < p < 0.05.

(c) All children in the 'yes' category for this variable had blood lead levels below 0.49 μmol/L so that is not possible to estimate the odds ratio.

(d) Highest income earned by any member of household.

(e) Includes nine hobbies practised by anyone in household which involve possible exposure to lead (see Table 23).

Logistic regression with environmental measures

The findings from testing of environmental specimens can be incorporated into a logistic regression model, using a subset of the data. This subset includes all children with blood lead levels greater than or equal to 0.49 µmol/L plus a systematic 40% random sample from all States and Territories of the remaining children, as in a case-control study ('Methods', page 21). The results of this analysis are shown in Table 53.

Table 52 shows that geometric mean lead loadings in dust, and geometric mean lead concentrations in water, soil and paint, are higher where blood lead level is greater than or equal to 0.49 µmol/L. The difference is highly statistically significant in all four cases. However, of the three environmental measures with substantial data, only dust lead loading and water concentration remain significant after adjusting for other variables (Table 53). Both of these show a strong association with the probability of a child having a blood lead level greater or equal to 0.49 µmol/L. Soil concentration is no longer statistically significantly associated with the probability of high blood lead level after controlling for dust loading, water concentration and other variables.

Table 52: Geometric means and geometric standard errors (gse) of lead levels in dust, soil, paint and water samples taken from the households of (a) a random sample of children with blood lead less than 0.49 µmol, and (b) all children whose blood lead level was greater than or equal to 0.49 µmol/L

	Random sample of children with blood lead < 0.49 µmol/L			All children with blood lead ≥ 0.49 µmol/L			
Measurement	n	Mean	gse	n	Mean	gse	t-statistic[a]
Dust loading (µg/900 cm^2)	552	0.23	1.05	111	0.50	1.14	6.3***
Water concentration (µg/L)	548	1.48	1.06	111	4.19	1.13	7.8***
Soil concentration (mg/kg)	541	24.0	1.07	107	61.4	1.17	5.8***
Paint concentration (mg/kg)	132	2,488	1.21	44	9,180	1.38	3.5***

(a) Statistical significance of t-test is indicated as *** p < 0.001, ** 0.001 < p < 0.01, * 0.01 < p < 0.05.

In the present model, the term for Broken Hill represents two children from one household with blood lead concentrations higher than would be expected from their values of other variables. There were no children from old South Australian stone houses in this sample, so this factor is not included in the model.

Age, income, year of house, presence of smoker in the household and frequency of eating soil are all statistically significantly associated with the likelihood of having a high blood lead level as in the previous logistic regression, and show similar patterns. The major difference for the variable 'year of house' is between homes built before and after 1980 (chi-square test for this dichotomy versus 6 categories for year of house gives $\chi^2_4 = 5.9$, $p > 0.05$). Children in post-1980 houses are less likely to have a high blood lead concentration than those in houses built before this date.

Table 53: Logistic regression model for blood lead level being equal to or greater than 0.49 μmol/L, for children from households for which environmental specimens have been analysed, comprising all children whose blood lead level was greater than or equal to 0.49 μmol/L plus a 40% random sample of children with blood lead less than 0.49 μmol/L (based on 653 children)

Variable	Category[(a)]	Chi-square statistic[(b)]	Log odds ratio		Odds ratio	
			Estimate	se	Estimate with 95% CI	
Intercept			–3.30	0.48	0.04	(0.01, 0.10)
Dust lead loading	log μg/900 cm^2	13.5***	0.41	0.11	1.51	(1.21, 1.88)
Water lead concentration	log μg/L	49.6***	0.68	0.11	1.97	(1.61, 2.42)
Broken Hill	*No*	7.9**				
	Yes		8.71	11.15	–[(c)]	
Age	*1 year*	9.8*				
	2 years		0.32	0.35	1.37	(0.69, 2.73)
	3 years		0.05	0.40	1.05	(0.48, 2.28)
	4 years		–1.01	0.51	0.36	(0.13, 0.98)
Income[(d)]	*> $20,000 pa*	7.6**				
	≤ $20,000 pa		0.77	0.28	2.17	(1.26, 3.74)
Year of house	*After 1980*	14.1*				
	1966–1980		1.06	0.36	2.88	(1.41, 5.88)
	1951–1965		0.41	0.44	1.51	(0.63, 3.60)
	1921–1950		0.51	0.44	1.67	(0.71, 3.93)
	Before 1921		1.39	0.48	4.00	(1.57, 10.2)
	Unknown		1.02	0.62	2.78	(0.82, 9.42)
Smoker in household	*No*	10.0**				
	Yes		0.87	0.28	2.39	(1.39, 4.11)
Eats soil	*Never*	15.7**				
	< once per week		0.42	0.37	1.52	(0.73, 3.14)
	> once per week		0.90	0.51	2.45	(0.89, 6.73)
	Every day		1.99	0.52	7.33	(2.64, 20.4)
Lead smelting[(e)]	*No*	5.4*				
	Yes		2.71	1.05	15.02	(1.91, 118)

(a) An italic entry indicates the reference category.

(b) Likelihood ratio chi-square with n–1 degrees of freedom, where n is the number of categories for the variable. Statistical significance of chi-square is indicated as *** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$.

(c) Both children in the 'yes' category for this variable had blood lead levels above 0.49 μmol/L so that is not possible to estimate the odds ratio.

(d) Highest income earned by any member of household.

(e) Any involvement by a member of the household.

In contrast to the previous logistic regression, cleanliness of household is not a statistically significant covariate. The association between this variable and the likelihood of having a high blood lead level disappears after adjusting for dust lead loading, water concentration and age of house. In particular, and as might be expected, cleanliness of house correlates negatively with dust lead loading (Table 35).

The association between the practice of one or more lead-related hobbies in the household and the likelihood of a child having a high blood lead level disappears after controlling for other variables, particularly dust lead loading.

The geometric mean for dust lead loading for households where one or more lead-related hobbies are practised is 0.31 µg/wipe but 0.24 µg/wipe for households in which no hobbies are practised (t-test for difference = 2.9, $p = 0.004$). This suggests that at least some of the hobbies are adding to the lead loading in household dust.

In this sample there were only four households in which an occupant was involved in lead smelting. Although this occupation may increase the risk of high blood lead levels for children in the household, more data would have to be examined to test this association properly.

There were 176 children from households with paint lead measurements. For these children there is a statistically significant association between paint lead concentration and the likelihood of having a blood lead concentration greater than or equal to 0.49 µmol/L (Table 52). This association remains statistically significant after adjustment for log dust lead loading and log water lead concentration ($F_{1,162} = 5.5$, $p < 0.05$). The linear regression with environmental variables suggested that the effect of severely peeling paint was to add to the dust lead loading. The present results suggest that peeling paint with a high lead concentration may possibly have a more direct part in causing high blood lead levels in a small number of children. However, the sample with paint lead measurements is too small for a definitive conclusion to be drawn.

Random effects regression analysis

Random effects regression analysis was carried out to test for the effect of intra-class correlation within CDs and the effect of correlations between children living in the same household. The four regression models described above were refitted with extra variance terms for CD and household.

The 1,575 children with blood lead measurements came from 1,300 households within 279 CDs. There were between 1 and 38 individual households per CD, and up to 4 children within a household. Most households (1,043 or 80%) had only 1 child with a blood lead measurement. Thus, out of the total of 1,575 children, about one-third were from households with more than one child in the study.

The variance components for both the CD level and the household level were statistically significantly different from zero in the random effects linear regression analysis for all children ($p < 0.001$ in both cases). The pattern of regression coefficients for the fixed part of the model was similar to that in Table 47 for the standard analysis. As expected, the significance levels of some terms were reduced, with the following terms having p values greater than 0.05: State/Territory ($p = 0.2$), state of interior paint work ($p = 0.1$), lead smelting ($p = 0.06$) and occupation involving scrap metal or solder ($p = 0.08$).

The results were similar for the linear regression on the subset of 757 children with environmental lead levels. Both variance components were statistically significantly different from zero and two terms lost significance as compared with the standard model in Table 49 (State/Territory and occupation involving scrap metal or solder).

In the logistic regression models, there was no evidence for a household variance component, but in the full data set of 1,575, the CD component was statistically significantly different from zero. Again the pattern of observed odds ratios was similar, but the marginal terms became non-significant. In the subset with the environmental data, there was no evidence for either a non-zero CD variance component or a household variance component.

Thus, the results of the regression models remain substantially the same after allowing for the correlations between children from the same CD and children within households, even though these correlations are significant.

Comparison of blood lead readings between laboratories

A random sample of blood specimens analysed by graphite furnace atomic absorption spectroscopy (GFAAS) at Royal North Shore Hospital (RNSH) was re-analysed by inductively coupled plasma mass spectrometry (ICPMS) at the Royal Prince Alfred Hospital (RPAH). Of the 141 specimens selected for second analysis, analysis by both laboratories was possible for 139 (8.8% of all specimens).

There was good agreement between the two laboratories and no evidence of any systematic errors or anomalous readings (Figure 8). The means and standard errors were similar (RNSH 0.2734 and 0.0119 µmol/L, RPAH 0.2746 and 0.0110 µmol/L). The difference in means was very small (0.0012 µmol/L) and not statistically significant ($t = 0.32$, $p = 0.74$). The RNSH reading was higher in 43% of cases, the RPAH reading in 47%, and the readings were the same in 10% of cases.

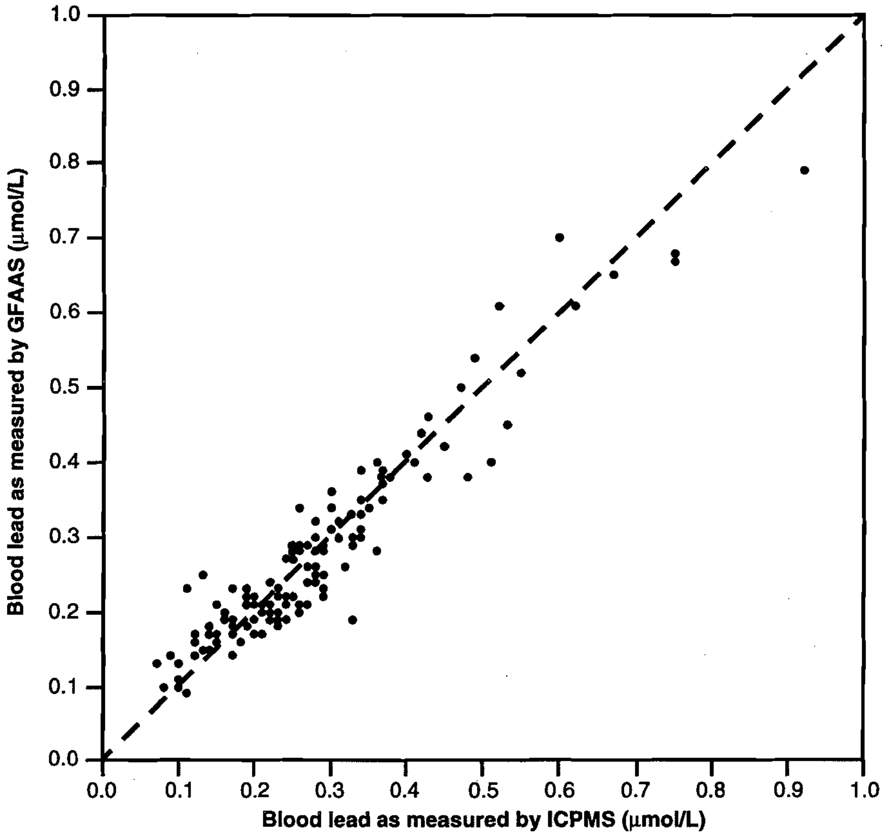


Figure 8: Comparison of blood lead readings done by GFAAS (graphite furnace atomic absorption spectroscopy, Royal North Shore Hospital) and ICPMS (inductively coupled plasma mass spectrometry, Royal Prince Alfred Hospital)

Factors influencing response

We have examined whether the children from whom blood specimens were obtained were representative of the population. For this we have compared Questionnaire characteristics of 1,575 children from whom a blood lead level was obtained and 1,232 children for whom this same information was obtained, but a blood lead level was not. Similarly we have compared Household Form characteristics of 1,575 children from whom a blood lead level was obtained and up to 1,478 children on whom this same information was obtained, but a blood lead level was not (see Table 8). The characteristics which have been compared are all those which are shown above to be associated with blood lead level.

The first characteristic where there is evidence of response bias is age of child. It is understandable that parents might not have been as willing to allow collection of blood from younger children. Children aged 1 year are under-represented in the blood collections, compared with older children (Table 54, $\chi^2_3 = 23.2$, $p < 0.001$). As younger children have higher blood lead levels than older children, the unadjusted national mean blood lead level of 0.277 μmol/L is less than the value adjusted for age of child, which is 0.278 μmol/L. The required correction is not of practical significance.

Table 54: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by age of child

	Blood specimen					
	Analysed		Not analysed		All	
Age of child	n	%	n	%	n	%
1 year	334	21.2	397	28.8	731	24.8
2 years	444	28.2	349	25.3	793	26.9
3 years	421	26.7	325	23.6	746	25.3
4 years	376	23.9	306	22.2	682	23.1
Total	**1,575**	**100.0**	**1,377**	**100.0**	**2,952**	**100.0**
Not stated			101		101	

Response, as measured by analysis of a blood specimen, was slightly higher among Aboriginal and Torres Strait Islander children than among other children (Table 55). The difference is not statistically significant ($\chi^2_1 = 0.26$, $p > 0.05$).

Table 55: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by identification as Aboriginal or Torres Strait Islander

	Blood specimen					
	Analysed		Not analysed		All	
Identification as Aboriginal or Torres Strait Islander	n	%	n	%	n	%
Yes	54	3.6	41	3.3	95	3.5
All other	1,441	96.4	1,217	96.7	2,658	96.5
Total	**1,495**	**100.0**	**1,258**	**100.0**	**2,753**	**100.0**
Not stated	80		220		300	

There is no evidence of any differences in response with the highest income group of any household member or with the highest education level of any household member (Tables 56 and 57; for income $\chi^2_5 = 4.5$, for education $\chi^2_4 = 8.5$, $p > 0.05$ in both cases).

One difference in response that was not anticipated was a higher proportion of blood collections and analyses where there was a smoker in the household (Table 58; $\chi^2_1 = 14.1$, $p < 0.001$). However, adjusting for this bias in response by weighting by the proportions of smoking and non-smoking households in the total sample makes little difference. The adjusted mean blood lead level is reduced only to 0.275 μmol/L from the 0.277 μmol/L actually found.

Table 56: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by income of highest earner in household

	Blood specimen					
	Analysed		Not analysed		All	
Income	n	%	n	%	n	%
< $12,000	138	9.3	130	10.7	268	9.9
$12,001–$20,000	248	16.7	174	14.3	422	15.6
$20,001–$30,000	353	23.8	294	24.2	647	24.0
$30,001–$40,000	353	23.8	283	23.3	636	23.6
$40,001–$50,000	186	12.5	149	12.3	335	12.4
> $50,000	208	14.0	184	15.2	392	14.5
Total	**1,486**	**100.0**	**1,214**	**100.0**	**2,700**	**100.0**
Not stated	89		264		353	

Table 57: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by highest level of education in household

	Blood specimen					
	Analysed		Not analysed		All	
Level of education	n	%	n	%	n	%
Bachelor's degree or higher	346	22.0	274	19.8	620	21.0
Trade qualification or apprenticeship	419	26.5	376	27.2	795	26.9
Certificate or diploma	324	20.6	249	18.0	573	19.4
Other higher education	13	0.8	16	1.1	29	1.0
No higher education or no response	473	30.1	469	33.9	942	31.8
Total	**1,575**	**100.0**	**1,384**	**100.0**	**2,959**	**100.0**
Not stated			94		94	

Table 58: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by presence of smoker in household

	Blood specimen					
	Analysed		Not analysed		All	
Presence of smokers	n	%	n	%	n	%
Smoker(s)	489	31.1	301	24.6	790	28.3
No smokers	1,084	68.9	921	75.4	2,005	71.7
Total	**1,573**	**100.0**	**1,222**	**100.0**	**2,795**	**100.0**
Not stated	2		256		258	

Response rate was not influenced by residence near a major road, but was higher in the small number of households with four or more vehicles using leaded petrol.

Response did not vary with cleanliness of the home. It was higher where there was chalking and/or peeling of internal and of external paint ($\chi^2_3 = 12.3$, $p < 0.01$). The findings for internal paint are shown in Table 59.

Table 59: Comparison of children from whom blood was analysed, and children from whom blood was not analysed, by condition of internal paintwork

	Blood specimen					
	Analysed		Not analysed		All	
Condition of paint	**n**	**%**	**n**	**%**	**n**	**%**
Severe chalking and/or peeling	57	3.6	21	1.7	78	2.8
Some chalking and/or peeling	421	26.9	299	24.6	720	25.9
No chalking and/or peeling	1,054	67.4	872	71.6	1,926	69.2
No internal paintwork	33	2.1	25	2.1	58	2.1
Total	**1,565**	**100.0**	**1,217**	**100.0**	**2,782**	**100.0**
Not stated	10		261		271	

Lead in cigarettes

Results of this testing are expressed in micrograms per cigarette in Table 60. The average lead per cigarette is 0.294 µg, and assuming all lead went into the sidestream smoke or was deposited as ash, smoking 20 cigarettes per day within a home would bring 2 mg lead into it in one year.

The geometric mean of dust lead loading for households with smokers was 0.29 µg/900 cm^2 compared with 0.23 µg/900 cm^2 for households without smokers. This difference was statistically significant ($t = 2.0$, $p < 0.05$, from 40% systematic random sample).

The average child in this survey was aged 3 years, and average weight would have been about 15 kg. The average excess lead level associated with smoking was 0.08 µmol/L, corresponding to an excess of 0.25 mg in the child's body.

Table 60: Lead content of 10 popular brands of Australian cigarettes

Brand of cigarette	Lead per cigarette (µg)
Longbeach ultra mild	0.48
Benson and Hedges extra mild	0.33
Peter Jackson supermild	0.31
Dunhill ultra mild	0.30
Horizon super mild	0.29
Alpine 1 mg	0.27
Winfield supermild	0.26
Winfield extramild	0.25
St Moritz ultramild	0.23
Marlboro ultra mild	0.22

Discussion

Distribution of blood lead levels

The first aim of the National Survey of Lead in Children was to ascertain the blood lead levels in a representative sample of Australian children aged 1 to 4 years. The survey has found an arithmetic mean blood lead level of 0.28 µmol/L (6 µg/dL in old units) and a geometric mean blood lead level of 0.24 µmol/L (5 µg/dL in old units). One of 1,575 readings was below 0.04 µmol/L (1 µg/dL), the limit of the analytical method used. At the other extreme, 7% of children aged 1 to 4 years had blood lead levels of 0.49 µmol/L (10 µg/dL) or higher, and 2% had levels of 0.73 µmol/L (15 µg/dL) or higher. The highest reading was 1.58 µmol/L (33 µg/dL).

The 1993 National Review of Public Exposure to Lead in Australia (Edwards-Bert, Calder & Maynard 1993) summarised studies from 1989. Although none of these studies was of a representative population sample, the review used them to estimate the percentages of children with blood lead concentrations exceeding various levels. The estimates are shown in Table 61, together with the findings from this survey. Lead levels in 1995 are very much lower than those estimated in 1993.

Table 61: Comparison of 1993 estimates of percentages of Australian children with blood lead concentrations exceeding those shown with survey findings

Blood lead level	≥ 0.49 µmol/L (≥ 10 µg/dL)	≥ 0.73 µmol/L (≥ 15 µg/dL)	≥ 0.97 µmol/L (≥ 20 µg/dL)	≥ 1.21 µmol/L (≥ 25 µg/dL)
1993 high estimate	53%	22%	8%	3%
1993 low estimate	26%	7%	3%	1%
1995 findings	7.3%	1.7%	0.6%	0.1%

Even though there had not been any systematic national survey before the present one, it was clear from the many earlier Australian studies that blood lead levels were generally decreasing. It was thus to be expected that 1995 blood lead levels would be below mean levels of 1993 and earlier years, and before the survey a mean blood lead level of 0.4 µmol/L (8 µg/dL) was anticipated. The arithmetic mean blood lead level of 0.28 µmol/L (6 µg/dL) and the geometric mean of 0.24 µmol/L (5 µg/dL) were thus appreciably less than what was expected on the basis of very limited previous data.

National target

In 1993, the 115th session of the National Health and Medical Research Council (NHMRC 1993) recommended as a goal the achievement for all Australians of a blood lead concentration of below 10 µg/dL. It noted there was particular urgency in reaching this level in children aged 1 to 4 years because of the adverse effects of lead exposure on intellectual development.

The 116th session later in 1993 set a specific target for blood lead levels in children. This was that, by 1998, 90% of Australian children should have blood lead levels below 0.49 μmol/L (10 μg/dL).

This target has already been surpassed: 93% of children aged 1 to 4 years have blood lead levels below 0.49 μmol/L.

Factors affecting blood lead level

The analyses have found many factors to be associated with blood lead level. Except for the cleanliness of the residence as assessed by the interviewer, they have been reported previously, most of them many times.

It is convenient to group the risk factors for purposes of discussion.

Social factors

This survey has, like others in almost all aspects of health, found better health (lower mean blood lead level) in socially advantaged families and worse health (higher mean blood lead level) in socially disadvantaged families.

Findings from the linear regression include that blood lead level is lower where a parent has a tertiary education; unfortunately, the form of the question asked prevented a more precise conclusion. The blood lead level is also lower where a member of the household has an annual income exceeding $20,000 per year than where no member has an income of this amount; this division corresponds closely to one or more family members being in full-time employment, or to none being in full-time employment.

Renting a home, as opposed to owning or purchasing one, is an indicator of disadvantage, but the differences in blood lead levels associated with renting appear to be explained by two environmental factors, i.e. the greater ages of rented homes and the poorer condition of paintwork in them.

Environmental factors

The survey included many questions about factors relating to lead in the physical environment, and measured lead in household specimens. The environment of individual children with the highest blood lead levels is reported, with findings of isotope distribution studies, in Appendix 4.

Environmental factors which the whole sample linear regression found to be associated with the child's blood lead level included cleanliness of the home, severely peeling interior paint, and year of construction of the home.

The amount of lead in a floor dust wipe is the product of the lead concentration in the dust and of the amount of dust in the standard area. The lead concentration should be expected to relate to factors including peeling interior paint and the concentration of lead in the paint, and the amount of dust should be expected to relate to cleanliness. The effect of severely deteriorating interior paint found in the full sample regression disappears in the regression in which floor dust loading is included. So does the effect of year of construction of the home, which may be an indirect measure of the concentration of lead in paint. However, the effect of cleanliness of the home persisted in the regression which included environmental measurements. It may be that the assessment of cleanliness is also measuring some additional factor, as yet unidentified.

It was shown in both linear regressions that the more frequently the child was found eating soil, the higher the blood lead level. Soil lead level was found to be a risk factor in the linear regression limited to households where it was measured. No relationship between exterior paint and blood lead level was found in either regression. It is reasonable to conclude that effects of deterioration of exterior paint have been expressed through these other risk factors.

Blood lead level was found to be associated with smoking in the household. The lead content of cigarettes and the higher mean lead loading in dust wipes of homes where there was smoking provide only a partial explanation of the association.

There were several specific occupational and hobby risk factors which showed as statistically significant in the linear regressions. For each there is a plausible mechanism by which children in affected households could be exposed to lead.

Ownership of one or more vehicles which use leaded petrol was associated with lead level in both linear regressions, but not in the logistic regressions, which relate to the probability of having a high blood lead level rather than to the mean blood lead level. The case histories of the children with the highest blood lead levels, summarised in Appendix 4, suggest that lead from petrol was of limited importance in determining their blood levels.

Findings from logistic regression were otherwise generally similar to those from linear regression.

Future action

The second aim of the National Survey of Lead in Children was to guide any further assessment of risk and/or development of targeted risk-reduction strategies by government which may be indicated by findings of the survey. Before these are considered, it is necessary to examine what present strategies will achieve.

Experience in the United States (Pirkle et al. 1994) has been that blood lead levels have decreased as the use of leaded petrol has decreased. At the time of the survey, 43% of petrol sold in Australia contained lead, at lower average concentrations than in 1994. The reductions in the percentage of petrol sold that contained lead, and in the lead concentration in leaded petrol, have been the major changes in lead use in Australia in recent years. In Sydney at least they had led to very much lower levels of lead in ambient air (Corbett S 1995 pers. comm.). They may therefore explain why blood lead levels found in this survey in 1995 were very much lower than estimated in 1993 (Edwards-Bert, Calder & Maynard 1993). If so, considerable further reductions in mean blood lead levels in children should be expected as the use of lead in petrol decreases.

It does not follow that the proportion of high blood lead levels will also decline rapidly or that the situation of the small minority of children with high blood lead levels will improve without action directed at lead sources other than petrol. The logistic regressions, with no effects relating to ownership of cars using leaded petrol, suggest this. The case histories of the children with notifiable levels show that few of these can be related to petrol, and although in most the immediate source of lead is house dust, its ultimate source is often not clear.

The future of national targets

The NHMRC noted that the concept of a 'level of concern' was no longer appropriate. Also, both the Centers for Disease Control (1991) and Schwartz (1994) have argued that there is no threshold for harmful effects of lead. With present methods of measuring both these effects and the levels to which blood lead levels have fallen, it may never be possible to demonstrate whether or not there is a threshold. Current NHMRC policy is that all exposure should be minimised, in effect meaning that there is no threshold. This policy should be continued.

Targets should be set only where public health action is planned or under consideration. Also, when there is no threshold or 'safe' level, it is not enough to set a target that everyone should have blood lead concentration below a specified level. If Australia requires targets in future, then because all lead exposure should be minimised, there should be targets for those with low exposure as well as high.

The existing targets recognise the particular problems of occupational exposure, and allow them as an exception to the general target. At least in respect of children, there could be benefit from setting additional targets in relation to individual occupational and hobby sources of lead where exposure can be modified.

New areas for action

Guidelines for reducing low-level exposure

Although the NHMRC has provided approaches to reduction of lead levels of 0.73 µmol/L (15 µg/dL) or higher, it has not given formal guidance about reducing lower levels.

Guidelines to assist parents to further reduce already low blood lead levels are needed. Rather than covering only the range 0.49 to 0.72 µmol/L, between the now abandoned level of concern and the lowest level for which there are existing guidelines, these guidelines should apply at all levels up to 0.72 µmol/L.

Paint

The findings of the logistic regressions implicate deteriorating lead-based paint. However, the isotope distribution studies do not provide as strong support as might have been expected. Deteriorating paint has been directly implicated in the cause of high blood lead levels in only a small percentage of children with very high levels. Although it is possible that survey staff sampled peeling paint from areas which did not have particularly high lead concentrations, many of the paint samples from older homes which might have been expected to contain lead did not do so.

The EPA recommends that prior to maintenance work residents test the paint of houses built before 1970. There are commercially available kits for testing whether paint contains lead. However, these kits can give both false positive and false negative results, so the EPA recommends laboratory analysis. The development of testing kits which give fewer false positive and false negative results is clearly desirable.

Guidelines advising householders and landlords how best to manage problems of deteriorating lead-based paint would also be useful.

Cleanliness of homes

The findings of this survey suggest that the guidelines referred to in the previous paragraph should cover cleanliness in the home, particularly on floors where children play. The lead loadings in dust relate well to blood lead level, and while it may not be easy to reduce the concentration of lead in dust, it is comparatively easy to reduce the amount of dust. If the quantity of dust can be reduced, reductions in blood lead levels should follow.

Smoking

Even though the findings in respect of smoking are not fully explained, the guidelines should also urge parents not to smoke. There are many other reasons parental smoking should be discouraged. They include prevention of respiratory disorders of childhood, and prevention of cot death. If the mother is pregnant again, smoking is also harmful to her unborn child. Public health action against smoking as a cause of high lead levels in children could be combined with action against these other effects.

Targeted education in automotive repair and panel-beating industries

Many of the hobbies which introduce lead to the home are essentially solitary activities, and except where there are magazines relating to the hobbies, it may be hard to communicate to these parents the need to minimise any exposure to lead which they cause. Labelling of hobby materials with warnings about lead may be possible.

In contrast, where the exposure is also occupational, for example in the automotive repair and panel-beating industries, where many workers practise their trades at home as well as at the workplace, there would seem to be many opportunities for targeted public health action, again including labelling of materials.

Appendix 1: Household Form

AUSTRALIAN INSTITUTE OF
HEALTH & WELFARE

In Confidence

National Survey of Lead in Children
Household Form

CCD	
Dwelling	
Household number	
Number of persons	
Number of children aged 1 to 4 years	

Address: ....
....
....

Further Identification: ....
....
....

IF THE NEED ARISES, MAY WE TELEPHONE YOU?

Yes ☐

No ☐

Telephone number

Best time(s) to call

Language for interview (if not English):

Date household form completed

Date of collection & interview

Details of Calls

	1st Call	2nd Call	3rd Call	4th Call	5th Call
Day					
Date					
Time Out					
Time In					
Total					

Appointments for blood collection, etc.
....
....
....
....
....
....
....
....
....

A	B		C		D	E	F	G
PNo	*Name*		*Relationship*		*Sex*	*Age*	*Date of Birth*	*Marital Status*
	What are the names of all the people who usually live here, starting with the head of the household? • *Complete Columns C to N for each UR*		**What is ..... relationship to the head of the household?**			**What was ..... age last birthday?** *If less than 1 year old record as "0"*	*If aged 5 years or less* **What was ..... date of birth?** *Record as: dd / mm / yy*	**What is ..... marital status?** Married = 1 De facto = 2 Separated = 3 Divorced = 4 Widowed = 5 Never married = 6
	Surname	Other names	To Head	Within Household	M = 1 F = 2			
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								

Scope Exclusions

- ALL visitors
- Overseas diplomats and members of non-Australian defence forces
- All persons in households with no URs aged 1 to 4 (HF completed in error)

O. Household Type

Interviewer: Tick Household Type on the basis of usual residents.

Married or de facto couple living ONLY with their child(ren) aged 0 - 14 .... ☐ 4

Married or de facto couple living ONLY with their child(ren) aged 0 - 14 and their unmarried child(ren) aged 15 or over .... ☐ 5

One person living ONLY with his/her child(ren) aged 0 - 14 ..... ☐ 7

One person living ONLY with his/her child(ren) aged 0 - 14 and his/her unmarried child(ren) aged 15 or over .... ☐ 8

All other households .... ☐ 9

P. Dwelling Location

Interviewer: Is this building within 25 metres of any major road?

Yes .... ☐ 1

No *(nothing further)* .... ☐ 2

Interviewer: Record the name(s) of this/these major road(s)

Major road 1

Major road 2

	H	I	J	K	L	M	N
	Aboriginal / TSI Origin	*Country of Birth*	*Year of Arrival*	*Age Left School*	*Educational Attainment*	*Income Group*	*Child Number*
	Is anyone who usually lives here of Aboriginal or Torres Strait Islander Origin? No = 1 Aboriginal = 2 TSI = 3 Both = 4	**In which country was ..... born?**	*If born overseas* **In what year did ..... arrive in Australia?**	*If aged 15 years or more* **At what age did ..... leave school?** Record Age Don't know =99 Still at school =98 Never went to school=97	*If aged 15 years or more AND left school* **Has ..... completed a trade certificate, diploma, degree or any other educational qualification?** *If yes, show PINK prompt card A and ask* **Which of these best describes the highest qualification ..... has completed?** Record Code	*If 15 years or older* *Show GREEN prompt card B* **Before tax is taken out, in which of these groups is ..... usual income from all sources?** Record Code	*If aged 1 to 4 years old* *Interviewer: number each child in this age group, starting at 1 and working down row by row*
01							
02							
03							
04							
05							
06							
07							
08							
09							
10							

Q. Dwelling Structure

Interviewer: Code best description of structure containing household

- Separate house .... ☐ 01
- Semi-detached / row or terrace house / townhouse:
  - One storey .... ☐ 02
  - Two or more storeys .... ☐ 03
- Flat attached to house .... ☐ 04
- Other flat / unit / apartment
  - One or two storeys .... ☐ 05
  - Three storeys .... ☐ 06
  - Four or more storeys .... ☐ 07
- Caravan .... ☐ 08
- Houseboat .... ☐ 09
- Improvised home / campers out .. ☐ 10
- House or flat attached to shops ... ☐ 11

R. External Walls - Main Material

Interviewer: Record the main material of the building's outside wall visible to you before interview

- Brick .... ☐ 1
- Stone .... ☐ 2
- Timber .... ☐ 3
- Fibro cement or other synthetic board .... ☐ 4
- Steel or aluminium .... ☐ 5
- Concrete .... ☐ 6
- Other *(specify)* .... ☐ 7
- Not visible at time of visit .... ☐ 8

S. External Walls - Condition of Paintwork

Interviewer: Record the condition of the building's external paintwork visible to you before interview

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ..... ☐ 2
- No chalking or peeling .... ☐ 3
- No paintwork .... ☐ 4
- Not visible at time of visit.......... ☐ 5

T. Estimated Year Built

Interviewer: Record your estimate of the year this dwelling was first built

Year 1 ☐☐☐

Response Reports

1. Interview

Interview fully complete ... ☐ 1

Interview partly complete

- part non-contact .... ☐ 2
- part refusal .... ☐ 3

Interview not obtained (no questionnaire)

- full non-contact .... ☐ 4
- full refusal .... ☐ 5

2. Dust Samples

a. Sample status

Sample obtained .... ☐ 1

Sample refused .... ☐ 2

Sample not collectable .... ☐ 3

b. Type of surface sampled

Carpet / rug .... ☐ 1

Wood .... ☐ 2

Linoleum .... ☐ 3

Ceramic tile .... ☐ 4

Other *(specify)* .... ☐ 5

☐

3. Soil Sample

Sample obtained .... ☐ 1

Sample refused .... ☐ 2

Sample not collectable .... ☐ 3

Sample not required (e.g. high rise, concrete surrounds) .... ☐ 4

4. Paint Sample

a. Sample status

Sample obtained .... ☐ 1

Sample refused .... ☐ 2

Sample not collectable .... ☐ 3

Sample not required (no severe peeling or chalking) .... ☐ 4

b. Paint source

Window sill .... ☐ 1

Skirting board .... ☐ 2

Wall .... ☐ 3

Other *(specify)* .... ☐ 4

☐

5. Water Samples

a. Sample status

Sample obtained .... ☐ 1

Sample refused .... ☐ 2

Sample not collectable .... ☐ 3

b. Number of samples

Number .... ☐

c. Type of samples

NB Do not collect bottled water

Mains/town water .... ☐ 1

Rainwater tank .... ☐ 2

Dam water .... ☐ 3

Bore water .... ☐ 4

Other *(specify)* .... ☐ 6

☐

d. When collected

First flush .... ☐ 1

At visit .... ☐ 2

Other *(specify)* .... ☐ 9

☐

6. Blood Samples

	Child 1	Child 2	Child 3	Child 4
Full 4 ml sample obtained	☐ 11	☐ 21	☐ 31	☐ 41
Sample obtained, less than 4 ml	☐ 12	☐ 22	☐ 32	☐ 42
Sample not obtained, child unwilling	☐ 13	☐ 23	☐ 33	☐ 43
Sample not obtained, parent refused	☐ 14	☐ 24	☐ 34	☐ 44
Sample not obtained, non-contact	☐ 15	☐ 25	☐ 35	☐ 45
Sample not attempted, other reason *(Attach / record details)*	☐ 19	☐ 29	☐ 39	☐ 49
Child's ID number				

Appendix 2: Questionnaire

AUSTRALIAN INSTITUTE OF HEALTH & WELFARE

In Confidence

National Survey of Lead in Children

Questionnaire

CCD	
Dwelling	
Household number	
Number of persons	
Number of children aged 1 to 4 years	

Interviewer:

- Explain the blood collection to the respondent.
- Get the respondent to complete the consent form IN FULL on the back of this questionnaire.
- Conduct the interview.
- Collect the environmental samples.

Date questionnaire completed

Comments

....

1. THE FIRST QUESTIONS ARE ABOUT CONTACT WITH POSSIBLE SOURCES OF LEAD.

HOW MANY CARS, MOTORBIKES, MOTOR SCOOTERS AND OTHER MOTOR VEHICLES DO MEMBERS OF THIS HOUSEHOLD HAVE?

Number ☐

None ... *(Go to Q3)* ☐ 9

2. (DOES IT/HOW MANY OF THESE) USE LEADED PETROL?

Interviewer: Diesel does not contain lead.

Number ☐

None ☐ 9

3. DOES ANYBODY USUALLY SMOKE INSIDE THIS *(specify dwelling type)*?

Yes ☐ 1

No ☐ 2

4. DOES ANYONE IN YOUR HOUSEHOLD HAVE A DOG?

Yes ☐ 1

No ☐ 2

5. DOES ANYONE IN YOUR HOUSEHOLD HAVE A CAT?

Yes ☐ 1

No ☐ 2

6. DO YOU HAVE A VEGETABLE GARDEN HERE?

Yes ☐ 1

No ☐ 2

7. *Interviewer: Show PINK card C*

DOES ANYBODY LIVING HERE WORK IN ANY OF THESE JOBS?

Building trades	*a*	☐	01
Any work in scrap metal industry	*b*	☐	02
Any work involving removal of paint	*c*	☐	03
Road construction or maintenance	*d*	☐	04
Any work with batteries	*e*	☐	05
Lead smelting	*f*	☐	06
Lead mining	*g*	☐	07
Any work with brass	*h*	☐	08
Any work using solder	*i*	☐	09
Manufacture of glass	*j*	☐	10
Automotive repair	*k*	☐	11
Panel beating	*l*	☐	12
None of the above	*m*	☐	13

8. *Interviewer: Show YELLOW card D*

DOES ANYBODY LIVING HERE DO ANY OF THESE FOR A HOBBY?

Home renovation involving removal of old paint	*a*	☐	01
Making pottery or ceramics	*b*	☐	02
Painting china	*c*	☐	03
Staining glass	*d*	☐	04
Playing games with lead models	*e*	☐	05
Making sinkers for fishing	*f*	☐	06
Shooting	*g*	☐	07
Panel beating or spray painting of cars	*h*	☐	08
Automotive repairs	*i*	☐	09
None of the above	*j*	☐	10

9. I WOULD NOW LIKE TO ASK YOU SOME QUESTIONS ABOUT THIS HOME.

IN WHAT MONTH AND YEAR WAS THIS *(specify dwelling type)* FIRST OCCUPIED BY YOUR HOUSEHOLD?

Month, year *(mm/yy)* ☐☐☐☐

10. AS CLOSELY AS YOU CAN TELL, IN WHAT YEAR WAS THIS *(specify dwelling type)* FIRST BUILT?

Year ... ... ☐☐☐☐

11. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE INTERNAL PAINTWORK?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ... ... ☐ 2
- No chalking or peeling ... ... ☐ 3
- No paintwork ... ... ☐ 4

12. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ... ... ☐ 2
- No chalking or peeling ... ... ☐ 3
- No paintwork ... ... ☐ 4

13. HAS ANY PAINT BEEN REMOVED AT THIS HOME DURING THE LAST 12 MONTHS?

- Yes ... ... ☐ 1
- No ... ... *(Go to Q15)* ☐ 2
- Don't know ... ... *(Go to Q15)* ☐ 3

14. DID YOUR CHILD(REN) CONTINUE TO LIVE HERE WHILE THE PAINT WAS BEING REMOVED?

- Yes ... ... ☐ 1
- No ... ... ☐ 2

15. *Interviewer: Show WHITE card F*

WHAT SOURCES OF WATER ARE USED IN THIS *(specify dwelling type)* FOR DRINKING AND COOKING?

- Mains / Town water ... ... *a* ☐ 1
- Rainwater tanks ... ... *b* ☐ 2
- Dams ... ... *c* ☐ 3
- Bores ... ... *d* ☐ 4
- Bottled water ... ... *e* ☐ 5
- Other *(specify)* ... ... *f* ☐ 6

16. *Sequence Guide*

- If rainwater tanks used *(Go to Q17)* ☐ 1
- Otherwise ... ... *(Go to Q18)* ☐ 2

17. WHAT IS THE MAIN MATERIAL THAT THE ROOF OF THIS *(specify dwelling type)* IS MADE OF?

- Tiles ... ... ☐ 1
- Metal Sheeting ... ... ☐ 2
- Slate ... ... ☐ 3
- Fibro ... ... ☐ 4
- Other *(specify)* ... ... ☐ 5
- Don't know ... ... ☐ 6

18. IS THIS *(specify dwelling type)*

- BEING PAID OFF BY SOMEONE IN THIS HOUSEHOLD? ... ... ☐ 1
- OWNED OUTRIGHT BY SOMEONE IN THIS HOUSEHOLD? ... ... ☐ 2
- RENTED BY SOMEONE IN THIS HOUSEHOLD? ... ... ☐ 3
- OCCUPIED RENT FREE? ... ... ☐ 4
- Other *(specify)* ... ... ☐ 5

19. *Interviewer: Enter Child 1's name from HF*

[ ]

20. THESE QUESTIONS ASK ABOUT *(Child 1)*.

Interviewer: Show GREEN card G

HOW OFTEN DOES .... SUCK (HIS/HER) FINGERS OR THUMB?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

21. *Interviewer: Show GREEN card G*

HOW OFTEN DOES ..... SUCK OR CHEW TOYS?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

22. *Interviewer: Show GREEN card G*

HOW OFTEN DO YOU FIND ..... EATING SOIL?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

23. *Interviewer: Show WHITE card H*

IS ..... USUALLY MINDED AWAY FROM HOME FOR MORE THAN HALF A DAY EACH WEEK IN ANY OF THESE LOCATIONS?

- Yes ... 1
- No ... *(Go to Q30)* 2

24. AT HOW MANY DIFFERENT ADDRESSES IS ..... USUALLY MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY A WEEK?

- Number ... [ ]
- One ... 1

25. FOR HOW MANY MONTHS HAS ..... BEEN MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY EACH WEEK?

- Number ... [ ]
- Less than one ... 99

26. *Interviewer: Show BLUE card E*

REFERRING TO THE GENERAL CONDITION OF THE INTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING ... 1
- SOME CHALKING AND/OR PEELING ... 2
- NO CHALKING OR PEELING ... 3
- NO PAINTWORK ... 4
- Don't know ... 5

27. *Interviewer: Show BLUE card E*

FOR THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING ... 1
- SOME CHALKING AND/OR PEELING ... 2
- NO CHALKING OR PEELING ... 3
- NO PAINTWORK ... 4
- Don't know ... 5

28. Sequence Guide

- If code 1 or 2 in either Q26 or Q27 ... *(Go to Q29)* 1
- Otherwise ... *(Go to Q30)* 2

29. AS CLOSELY AS YOU CAN TELL, (WAS THIS/WERE ANY OF THESE) BUILDING(S) BUILT BEFORE 1970?

- Yes ... 1
- No ... 2

30. HAS ..... LIVED ANYWHERE ELSE IN THE LAST SIX MONTHS?

- Yes ... 1
- No ... *(Go to Q42)* 2

31. DID (HE/SHE) LIVE THERE FOR AT LEAST THREE MONTHS OUT OF THE SIX?

- Yes ... 1
- No ... *(Go to Q42)* 2

32. IN WHAT MONTH AND YEAR DID ..... MOVE IN TO THAT ADDRESS?

Month, year *(mm/yy)* ☐☐☐☐

33. IN WHAT MONTH AND YEAR DID ..... MOVE OUT FROM THERE?

Month, year *(mm/yy)* ☐☐☐☐

34. AS CLOSELY AS YOU CAN TELL, IN WHAT YEAR WAS THAT BUILDING FIRST BUILT?

Year ... ☐☐☐☐

35. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE INTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... 1
- Some chalking and/or peeling ... 2
- No chalking or peeling ... 3
- No paintwork ... 4

36. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... 1
- Some chalking and/or peeling ... 2
- No chalking or peeling ... 3
- No paintwork ... 4

37. HAS ANY PAINT BEEN REMOVED FROM THAT BUILDING DURING THE LAST 12 MONTHS?

- Yes ... 1
- No ... *(Go to Q39)* 2
- Don't know ... *(Go to Q39)* 3

38. DID ..... CONTINUE TO LIVE THERE WHILE THE PAINT WAS BEING REMOVED?

- Yes ... 1
- No ... 2

39. WHAT WAS THE MAIN MATERIAL OF THE EXTERNAL WALLS OF THAT BUILDING?

- Brick ... 1
- Stone ... 2
- Timber ... 3
- Fibro cement or other synthetic board 4
- Steel or aluminium ... 5
- Concrete ... 6
- Other *(specify)* ... 7
- Don't know ... 8

40. DID THAT BUILDING HAVE A VEGETABLE GARDEN?

- Yes ... 1
- No ... 2
- Don't know ... 3

41. WAS THAT BUILDING WITHIN 25 METRES OF A MAJOR ROAD?

Yes ... 1
No ... 2
Don't know ... 3

42. AND NOW SOME OTHER HEALTH-RELATED QUESTIONS ABOUT .....

HAS .... EVER HAD MEASLES?

Yes ... 1
No ... 2

43. HAS ..... EVER BEEN GIVEN ANY INJECTIONS AGAINST MEASLES?

Yes ... 1
No ... 2
Don't know ... 3

44. *Interviewer: Were records produced?*

Yes ... 1
No ... 2

45. DOES ..... EAT BEEF, LAMB AND/OR PORK?

Yes ... 1
No ... 2

46. DOES ..... EAT CHICKEN AND/OR FISH?

Yes ... 1
No ... 2

47. IS ..... TAKING ANY VITAMIN OR MINERAL SUPPLEMENTS?

Yes ... 1
No ... *(Go to Q49)* 2

48. COULD YOU PLEASE SHOW ME THE PACKAGING SO THAT I CAN WRITE DOWN THE SUPPLEMENT'S NAME?

Number of packages produced ... *a*

Product 1 ... *b*

Product 2 ... *c*

Product 3 ... *d*

Product 4 ... *e*

49. *Interviewer:*

Blood consent form signed *(Go to Q50)* 1
Otherwise ... *(Go to Q51)* 2

50. *Interviewer:*

4 ml sample obtained ... 1
Less than 4ml sample obtained ... 2
No sample obtained ... 3

51. *Sequence Guide*

One child only in household ... *(Go to Q162)* 1
Otherwise ... *(Go to Q52)* 2

52. *Interviewer: Enter Child 2's name from HF*

[ ]

53. THESE QUESTIONS ASK ABOUT *(Child 2)*.

Interviewer: Show GREEN card G

HOW OFTEN DOES .... SUCK (HIS/HER) FINGERS OR THUMB?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

54. *Interviewer: Show GREEN card G*

HOW OFTEN DOES ..... SUCK OR CHEW TOYS?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

55. *Interviewer: Show GREEN card G*

HOW OFTEN DO YOU FIND ..... EATING SOIL?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

56. *Interviewer: Show WHITE card H*

IS ..... USUALLY MINDED AWAY FROM HOME FOR MORE THAN HALF A DAY EACH WEEK IN ANY OF THESE LOCATIONS?

- Yes ... 1
- No ... *(Go to Q65)* 2

57. AT HOW MANY DIFFERENT ADDRESSES IS ..... USUALLY MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY A WEEK?

- Number ... [ ]
- One ... 1

58. FOR HOW MANY MONTHS HAS ..... BEEN MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY EACH WEEK?

- Number ... [ ]
- Less than one ... 99

59. *Sequence Guide*

- Child 1 minded elsewhere (code 1 in Q23) ... *(Go to Q60)* 1
- Otherwise ... *(Go to Q61)* 2

60. (IS THIS/ARE ALL OF THESE) ADDRESS(ES) THE SAME AS FOR (child 1 name)?

- Yes ... *(Go to Q65)* 1
- No ... 2

61. *Interviewer: Show BLUE card E*

REFERRING TO THE GENERAL CONDITION OF THE INTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING ... 1
- SOME CHALKING AND/OR PEELING ... 2
- NO CHALKING OR PEELING ... 3
- NO PAINTWORK ... 4
- Don't know ... 5

62. *Interviewer: Show BLUE card E*

FOR THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING .... ☐ 1
- SOME CHALKING AND/OR PEELING .... ☐ 2
- NO CHALKING OR PEELING ...... ☐ 3
- NO PAINTWORK .... ☐ 4
- Don't know .... ☐ 5

63. *Sequence Guide*

- If code 1 or 2 in either Q61 or Q62 .... *(Go to Q64)* ☐ 1
- Otherwise .... *(Go to Q65)* ☐ 2

64. AS CLOSELY AS YOU CAN TELL, (WAS THIS/WERE ANY OF THESE) BUILDING(S) BUILT BEFORE 1970?

- Yes .... ☐ 1
- No .... ☐ 2

65. HAS ..... LIVED ANYWHERE ELSE IN THE LAST SIX MONTHS?

- Yes .... ☐ 1
- No .... *(Go to Q79)* ☐ 2

66. DID (HE/SHE) LIVE THERE FOR AT LEAST THREE MONTHS OUT OF THE SIX?

- Yes .... ☐ 1
- No .... *(Go to Q79)* ☐ 2

67. *Sequence Guide*

- Child 1 lived elsewhere 3 months or more (code 1 in Q31) *(Go to Q68)* ☐ 1
- Otherwise .... *(Go to Q69)* ☐ 2

68. IS THIS ADDRESS THE SAME AS FOR (Child 1 name)?

- Yes .... *(Go to Q79)* ☐ 1
- No .... ☐ 2

69. IN WHAT MONTH AND YEAR DID ..... MOVE IN TO THAT ADDRESS?

Month, year *(mm/yy)* ☐☐☐☐

70. IN WHAT MONTH AND YEAR DID ..... MOVE OUT FROM THERE?

Month, year *(mm/yy)* ☐☐☐☐

71. AS CLOSELY AS YOU CAN TELL, IN WHAT YEAR WAS THAT BUILDING FIRST BUILT?

Year .... ☐☐☐☐

72. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE INTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ...... ☐ 2
- No chalking or peeling .... ☐ 3
- No paintwork .... ☐ 4

73. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ...... ☐ 2
- No chalking or peeling .... ☐ 3
- No paintwork .... ☐ 4

74. HAS ANY PAINT BEEN REMOVED FROM THAT BUILDING DURING THE LAST 12 MONTHS?

- Yes .... ☐ 1
- No .... *(Go to Q76)* ☐ 2
- Don't know .... *(Go to Q76)* ☐ 3

75. DID ..... CONTINUE TO LIVE THERE WHILE THE PAINT WAS BEING REMOVED?

- Yes .... ☐ 1
- No .... ☐ 2

76. WHAT WAS THE MAIN MATERIAL OF THE EXTERNAL WALLS OF THAT BUILDING?

- Brick ... 1
- Stone ... 2
- Timber ... 3
- Fibro cement or other synthetic board 4
- Steel or aluminium ... 5
- Concrete ... 6
- Other *(specify)* ... 7
- Don't know ... 8

77. DID THAT BUILDING HAVE A VEGETABLE GARDEN?

- Yes ... 1
- No ... 2
- Don't know ... 3

78. WAS THAT BUILDING WITHIN 25 METRES OF A MAJOR ROAD?

- Yes ... 1
- No ... 2
- Don't know ... 3

79. AND NOW SOME OTHER HEALTH-RELATED QUESTIONS ABOUT .....
HAS .... EVER HAD MEASLES?

- Yes ... 1
- No ... 2

80. HAS ..... EVER BEEN GIVEN ANY INJECTIONS AGAINST MEASLES?

- Yes ... 1
- No ... 2
- Don't know ... 3

81. *Interviewer: Were records produced?*

- Yes ... 1
- No ... 2

82. DOES ..... EAT BEEF, LAMB AND/OR PORK?

- Yes ... 1
- No ... 2

83. DOES ..... EAT CHICKEN AND/OR FISH?

- Yes ... 1
- No ... 2

84. IS ..... TAKING ANY VITAMIN OR MINERAL SUPPLEMENTS?

- Yes ... 1
- No ... *(Go to Q86)* 2

85. COULD YOU PLEASE SHOW ME THE PACKAGING SO THAT I CAN WRITE DOWN THE SUPPLEMENT'S NAME?

- Number of packages produced ... *a*
- Product 1 *b*
- Product 2 *c*
- Product 3 *d*
- Product 4 *e*

86. *Interviewer:*

- Blood consent form signed *(Go to Q87)* 1
- Otherwise ... *(Go to Q88)* 2

87. *Interviewer:*

- 4 ml sample obtained ... 1
- Less than 4ml sample obtained ... 2
- No sample obtained ... 3

88. *Sequence Guide*

- 2 children only in household ... *(Go to Q162)* 1
- Otherwise ... *(Go to Q89)* 2

89. *Interviewer: Enter Child 3's name from HF*

[ ]

90. THESE QUESTIONS ASK ABOUT *(Child 3)*.

Interviewer: Show GREEN card G

HOW OFTEN DOES ..... SUCK (HIS/HER) FINGERS OR THUMB?

- Every day 1
- More than once a week 2
- Less than once a week 3
- Never 4

91. *Interviewer: Show GREEN card G*

HOW OFTEN DOES ..... SUCK OR CHEW TOYS?

- Every day 1
- More than once a week 2
- Less than once a week 3
- Never 4

92. *Interviewer: Show GREEN card G*

HOW OFTEN DO YOU FIND ..... EATING SOIL?

- Every day 1
- More than once a week 2
- Less than once a week 3
- Never 4

93. *Interviewer: Show WHITE card H*

IS ..... USUALLY MINDED AWAY FROM HOME FOR MORE THAN HALF A DAY EACH WEEK IN ANY OF THESE LOCATIONS?

- Yes 1
- No .... *(Go to Q102)* 2

94. AT HOW MANY DIFFERENT ADDRESSES IS ..... USUALLY MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY A WEEK?

- Number .... [ ]
- One 1

95. FOR HOW MANY MONTHS HAS ..... BEEN MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY EACH WEEK?

- Number .... [ ]
- Less than one 99

96. Sequence Guide

- Child 1 minded elsewhere (code 1 in Q23) ...... *(Go to Q97)* 1
- Child 2 minded elsewhere (code 2 in Q60) ...... *(Go to Q97)* 2
- Otherwise .... *(Go to Q98)* 3

97. (IS THIS/ARE ALL OF THESE) THE SAME ADDRESSES AS FOR

Interviewer: Read out children's names as applicable.

- (Child 1 name)'s ... *(Go to Q102)* 1
- (Child 2 name)'s ... *(Go to Q102)* 2
- No 3

98. *Interviewer: Show BLUE card E*

REFERRING TO THE GENERAL CONDITION OF THE INTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING 1
- SOME CHALKING AND/OR PEELING 2
- NO CHALKING OR PEELING 3
- NO PAINTWORK 4
- Don't know 5

99. *Interviewer: Show BLUE card E*

FOR THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

SEVERE CHALKING AND/OR PEELING ... ☐ 1
SOME CHALKING AND/OR PEELING ... ☐ 2
NO CHALKING OR PEELING ... ☐ 3
NO PAINTWORK ... ☐ 4
Don't know ... ☐ 5

100. *Sequence Guide*

If code 1 or 2 in either Q98 or Q99 ... (Go to Q101) ☐ 1
Otherwise ... (Go to Q102) ☐ 2

101. AS CLOSELY AS YOU CAN TELL, (WAS THIS/WERE ANY OF THESE) BUILDING(S) BUILT BEFORE 1970?

Yes ... ☐ 1
No ... ☐ 2

102. HAS ..... LIVED ANYWHERE ELSE IN THE LAST SIX MONTHS?

Yes ... ☐ 1
No ... *(Go to Q116)* ☐ 2

103. DID (HE/SHE) LIVE THERE FOR AT LEAST THREE MONTHS OUT OF THE SIX?

Yes ... ☐ 1
No ... *(Go to Q116)* ☐ 2

104. *Sequence Guide*

Child 1 lived elsewhere 3 months or more (code 1 in Q31) *(Go to Q105)* ☐ 1
Child 2 lived elsewhere 3 months or more (code 1 in Q66) *(Go to Q105)* ☐ 2
Otherwise ... *(Go to Q106)* ☐ 3

105. IS THIS ADDRESS THE SAME AS

Interviewer: Read out names as applicable.

(Child 1 name)'s? ... *(Go to Q116)* ☐ 1
(Child 2 name)'s? ... *(Go to Q116)* ☐ 2
No ... ☐ 3

106. IN WHAT MONTH AND YEAR DID ..... MOVE IN TO THAT ADDRESS?

Month, year *(mm/yy)* ☐☐☐☐

107. IN WHAT MONTH AND YEAR DID ..... MOVE OUT FROM THERE?

Month, year *(mm/yy)* ☐☐☐☐

108. AS CLOSELY AS YOU CAN TELL, IN WHAT YEAR WAS THAT BUILDING FIRST BUILT?

Year ... ☐☐☐☐

109. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE INTERNAL PAINTWORK THERE?

Severe chalking and/or peeling ... ☐ 1
Some chalking and/or peeling ... ☐ 2
No chalking or peeling ... ☐ 3
No paintwork ... ☐ 4

110. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK THERE?

Severe chalking and/or peeling ... ☐ 1
Some chalking and/or peeling ... ☐ 2
No chalking or peeling ... ☐ 3
No paintwork ... ☐ 4

111. HAS ANY PAINT BEEN REMOVED FROM THAT BUILDING DURING THE LAST 12 MONTHS?

Yes ... ☐ 1
No ... *(Go to Q113)* ☐ 2
Don't know ... *(Go to Q113)* ☐ 3

112. DID ..... CONTINUE TO LIVE THERE WHILE THE PAINT WAS BEING REMOVED?

Yes ... ☐ 1
No ... ☐ 2

113. WHAT WAS THE MAIN MATERIAL OF THE EXTERNAL WALLS OF THAT BUILDING?
- Brick ... ☐ 1
- Stone ... ☐ 2
- Timber ... ☐ 3
- Fibro cement or other synthetic board ☐ 4
- Steel or aluminium ... ☐ 5
- Concrete ... ☐ 6
- Other *(specify)* ... ☐ 7
- Don't know ... ☐ 8

114. DID THAT BUILDING HAVE A VEGETABLE GARDEN?
- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

115. WAS THAT BUILDING WITHIN 25 METRES OF A MAJOR ROAD?
- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

116. AND NOW SOME OTHER HEALTH-RELATED QUESTIONS ABOUT .....

HAS .... EVER HAD MEASLES?
- Yes ... ☐ 1
- No ... ☐ 2

117. HAS ..... EVER BEEN GIVEN ANY INJECTIONS AGAINST MEASLES?
- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

118. *Interviewer: Were records produced?*
- Yes ... ☐ 1
- No ... ☐ 2

119. DOES ..... EAT BEEF, LAMB AND/OR PORK?
- Yes ... ☐ 1
- No ... ☐ 2

120. DOES ..... EAT CHICKEN AND/OR FISH?
- Yes ... ☐ 1
- No ... ☐ 2

121. IS ..... TAKING ANY VITAMIN OR MINERAL SUPPLEMENTS?
- Yes ... ☐ 1
- No ... *(Go to Q123)* ☐ 2

122. COULD YOU PLEASE SHOW ME THE PACKAGING SO THAT I CAN WRITE DOWN THE SUPPLEMENT'S NAME?

Number of packages produced ... *a* ☐

Product 1 ______ *b* ☐

Product 2 ______ *c* ☐

Product 3 ______ *d* ☐

Product 4 ______ *e* ☐

123. *Interviewer:*
- Blood consent form signed *(Go to Q124)* ☐ 1
- Otherwise ... *(Go to Q125)* ☐ 2

124. *Interviewer:*
- 4 ml sample obtained ... ☐ 1
- Less than 4ml sample obtained ... ☐ 2
- No sample obtained ... ☐ 3

125. *Sequence Guide*
- 3 children only in household ... *(Go to Q162)* ☐ 1
- Otherwise ... *(Go to Q126)* ☐ 2

126. *Interviewer: Enter Child 4's name from HF*

[ ]

127. THESE QUESTIONS ASK ABOUT *(Child 4)*.

Interviewer: Show GREEN card G

HOW OFTEN DOES .... SUCK (HIS/HER) FINGERS OR THUMB?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

128. *Interviewer: Show GREEN card G*

HOW OFTEN DOES ..... SUCK OR CHEW TOYS?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

129. *Interviewer: Show GREEN card G*

HOW OFTEN DO YOU FIND ..... EATING SOIL?

- Every day ... 1
- More than once a week ... 2
- Less than once a week ... 3
- Never ... 4

130. *Interviewer: Show WHITE card H*

IS ..... USUALLY MINDED AWAY FROM HOME FOR MORE THAN HALF A DAY EACH WEEK IN ANY OF THESE LOCATIONS?

- Yes ... 1
- No ... *(Go to Q139)* 2

131. AT HOW MANY DIFFERENT ADDRESSES IS ..... USUALLY MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY A WEEK?

- Number ... [ ]
- One ... 1

132. FOR HOW MANY MONTHS HAS ..... BEEN MINDED AWAY FROM HOME FOR AT LEAST HALF A DAY EACH WEEK?

- Number ... [ ]
- Less than one ... 99

133. *Sequence Guide*

- Child 1 minded elsewhere (code 1 in Q23) ... *(Go to Q134)* 1
- Child 2 minded elsewhere (code 2 in Q60) ... *(Go to Q134)* 2
- Child 3 minded elsewhere (code 3 in Q97) ... *(Go to Q134)* 3
- Otherwise ... *(Go to Q135)* 4

134. (IS THIS/ARE ALL OF THESE) ADDRESSES THE SAME AS FOR

Interviewer: Read out names as applicable.

- (Child 1 name)'s ... *(Go to Q139)* 1
- (Child 2 name)'s ... *(Go to Q139)* 2
- (Child 3 name)'s ... *(Go to Q139)* 3
- No ... 4

135. *Interviewer: Show BLUE card E*

REFERRING TO THE GENERAL CONDITION OF THE INTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING ... 1
- SOME CHALKING AND/OR PEELING ... 2
- NO CHALKING OR PEELING ... 3
- NO PAINTWORK ... 4
- Don't know ... 5

136. *Interviewer: Show BLUE card E*

FOR THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK, (DOES THIS/DO ANY OF THESE) BUILDING(S) HAVE

- SEVERE CHALKING AND/OR PEELING ... ☐ 1
- SOME CHALKING AND/OR PEELING ... ☐ 2
- NO CHALKING OR PEELING ... ☐ 3
- NO PAINTWORK ... ☐ 4
- Don't know ... ☐ 5

137. *Sequence Guide*

- If code 1 or 2 in either Q135 or Q136 ... *(Go to Q138)* ☐ 1
- Otherwise ... *(Go to Q139)* ☐ 2

138. AS CLOSELY AS YOU CAN TELL, (WAS THIS/WERE ANY OF THESE) BUILDING(S) BUILT BEFORE 1970?

- Yes ... ☐ 1
- No ... ☐ 2

139. HAS ..... LIVED ANYWHERE ELSE IN THE LAST SIX MONTHS?

- Yes ... ☐ 1
- No ... *(Go to Q153)* ☐ 2

140. DID (HE/SHE) LIVE THERE FOR AT LEAST THREE MONTHS OUT OF THE SIX?

- Yes ... ☐ 1
- No ... *(Go to Q153)* ☐ 2

141. *Sequence Guide*

- Child 1 lived elsewhere 3 months or more (code 1 in Q31) *(Go to Q142)* ☐ 1
- Child 2 lived elsewhere 3 months or more (code 1 in Q66) *(Go to Q142)* ☐ 2
- Child 3 lived elsewhere 3 months or more (code 1 in Q103) *(Go to Q142)* ☐ 3
- Otherwise ... *(Go to Q143)* ☐ 4

142. IS THIS ADDRESS THE SAME AS FOR

Interviewer: Read out names as applicable.

- (Child 1 name)'s? ... *(Go to Q153)* ☐ 1
- (Child 2 name)'s? ... *(Go to Q153)* ☐ 2
- (Child 3 name)'s? ... *(Go to Q153)* ☐ 3
- No ... ☐ 4

143. IN WHAT MONTH AND YEAR DID ..... MOVE IN TO THAT ADDRESS?

Month, year *(mm/yy)* ☐☐☐☐

144. IN WHAT MONTH AND YEAR DID ..... MOVE OUT FROM THERE?

Month, year *(mm/yy)* ☐☐☐☐

145. AS CLOSELY AS YOU CAN TELL, IN WHAT YEAR WAS THAT BUILDING FIRST BUILT?

Year ... ☐☐☐☐

146. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE INTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ... ☐ 2
- No chalking or peeling ... ☐ 3
- No paintwork ... ☐ 4

147. *Interviewer: Show BLUE card E*

WHICH OF THESE BEST DESCRIBES THE GENERAL CONDITION OF THE EXTERNAL PAINTWORK THERE?

- Severe chalking and/or peeling ... ☐ 1
- Some chalking and/or peeling ... ☐ 2
- No chalking or peeling ... ☐ 3
- No paintwork ... ☐ 4

148. HAS ANY PAINT BEEN REMOVED FROM THAT BUILDING DURING THE LAST 12 MONTHS?

- Yes ... ☐ 1
- No ... *(Go to Q153)* ☐ 2
- Don't know ... *(Go to Q153)* ☐ 3

149. DID ..... CONTINUE TO LIVE THERE WHILE THE PAINT WAS BEING REMOVED?

- Yes ... ☐ 1
- No ... ☐ 2

150. WHAT WAS THE MAIN MATERIAL OF THE EXTERNAL WALLS OF THAT BUILDING?

- Brick ... ☐ 1
- Stone ... ☐ 2
- Timber ... ☐ 3
- Fibro cement or other synthetic board ☐ 4
- Steel or aluminium ... ☐ 5
- Concrete ... ☐ 6
- Other *(specify)* ... ☐ 7
- Don't know ... ☐ 8

151. DID THAT BUILDING HAVE A VEGETABLE GARDEN?

- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

152. WAS THAT BUILDING WITHIN 25 METRES OF A MAJOR ROAD?

- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

153. AND NOW SOME OTHER HEALTH-RELATED QUESTIONS ABOUT .....

HAS .... EVER HAD MEASLES?

- Yes ... ☐ 1
- No ... ☐ 2

154. HAS ..... EVER BEEN GIVEN ANY INJECTIONS AGAINST MEASLES?

- Yes ... ☐ 1
- No ... ☐ 2
- Don't know ... ☐ 3

155. *Interviewer: Were records produced?*

- Yes ... ☐ 1
- No ... ☐ 2

156. DOES ..... EAT BEEF, LAMB AND/OR PORK?

- Yes ... ☐ 1
- No ... ☐ 2

157. DOES ..... EAT CHICKEN AND/OR FISH?

- Yes ... ☐ 1
- No ... ☐ 2

158. IS ..... TAKING ANY VITAMIN OR MINERAL SUPPLEMENTS?

- Yes ... ☐ 1
- No ... *(Go to Q160)* ☐ 2

159. COULD YOU PLEASE SHOW ME THE PACKAGING SO THAT I CAN WRITE DOWN THE SUPPLEMENT'S NAME?

- Number of packages produced ... *a* ☐
- Product 1 ... *b* ☐
- Product 2 ... *c* ☐
- Product 3 ... *d* ☐
- Product 4 ... *e* ☐

160. *Interviewer:*

- Blood consent form signed *(Go to Q161)* ☐ 1
- Otherwise ... *(Go to Q162)* ☐ 2

161. *Interviewer:*

- 4 ml sample obtained ... ☐ 1
- Less than 4ml sample obtained ... ☐ 2
- No sample obtained ... ☐ 3

162. *Interviewer: (during editing) please rate the cleanliness of the household.*

- Very dirty ... ☐ 1
- Dirtier than average ... ☐ 2
- Average ... ☐ 3
- Cleaner than average ... ☐ 4
- Very clean ... ☐ 5

163. *No more questions.*

National Survey of Lead in Children

Consent Form for Blood Collection

Section 1. Name and address of parent or legal guardian giving consent.

Given names of parent / legal guardian | **Surname of parent / legal guardian**

Contact address

Suburb | **State** | **Post Code**

Section 2. Children aged 1 to 4 years covered by this form.

Given name of Child 1 | **Surname of Child 1**

Given name of Child 2 | **Surname of Child 2**

Given name of Child 3 | **Surname of Child 3**

Given name of Child 4 | **Surname of Child 4**

I agree that a representative of the Australian Institute of Health and Welfare (AIHW) may take a sample of approximately 4 ml of blood from the child or children aged 1 to 4 years listed above.

I understand that the AIHW will inform me of the results of blood lead testing, and whether these results require any action to be taken.

(Tick below if agreed)

☐ I authorise the AIHW to send a copy of the results of the testing to my family doctor (complete name and address details below).

☐ I authorise the AIHW to notify the results to the Health Department in this State or Territory if my child's blood lead level is found to exceed 15µg/dL.

Signature of parent / legal guardian

Complete this section only if you also want us to send results to your family doctor

Name of doctor

Address of doctor

Suburb | **State** | **Post Code**

Appendix 3: Text of Prompt Cards

A

1. Bachelor degree or higher
2. Trade qualification/apprenticeship
3. Certificate or diploma
4. Other

B

TOTAL INCOME FROM ALL SOURCES
BEFORE tax or anything else was taken out

	Weekly	Yearly
01.	$ Less than 58	$ Less than 3001
02.	$ 58 - 96	$ 3001 - 5000
03.	$ 97 - 154	$ 5001 - 8000
04.	$ 155 - 230	$ 8001 - 12,000
05.	$ 231 - 308	$ 12,001 - 16,000
06.	$ 309 - 385	$ 16,001 - 20,000
07.	$ 386 - 481	$ 20,001 - 25,000
08.	$ 482 - 577	$ 25,001 - 30,000
09.	$ 578 - 673	$ 30,001 - 35,000
10.	$ 674 - 769	$ 35,001 - 40,000
11.	$ 770 - 961	$ 40,001 - 50,000
12.	$ 962 - 1154	$ 50,001 - 60,000
13.	$ 1155 - 1346	$ 60,001 - 70,000
14.	$ More than 1346	$ More than 70,000

Note: You do not have to answer this question if you do not wish to.

C

01. Building trades
02. Any work in scrap metal industry
03. Any work involving removal of paint
04. Road construction or maintenance
05. Any work with batteries
06. Lead smelting
07. Lead mining
08. Any work with brass
09. Any work using solder
10. Manufacture of glass
11. Automotive repair
12. Panel beating
13. None of the above

D

01. Home renovation involving removal of old paint
02. Making pottery or ceramics
03. Painting china
04. Staining glass
05. Playing games with lead models
06. Making sinkers for fishing
07. Shooting
08. Panel beating or spray painting of cars
09. Automotive repairs
10. None of the above

E

Please note:
Chalking is when paint becomes powdery and brushes off easily
Peeling means sections of paint falling off.
Minor cracking does not count as chalking or peeling.

1. Severe chalking and/or peeling
2. Some chalking and/or peeling
3. No chalking or peeling
4. No paintwork

F

1. Mains/ Town water
2. Rainwater tanks
3. Dams
4. Bores
5. Bottled water
6. Other (please specify)

G

1. Every day
2. More than once a week
3. Less than once a week
4. Never

H

<u>Any Informal Care, for example:</u>

01. Relative's home
02. Friend's home
03. Babysitter's home
04. Any other informal care away from home

<u>Any Formal Care, for example:</u>

05. Family day care
06. Occasional care centre
07. Long day care centre
08. Kindergarten
09. Pre-school
10. Any other formal care away from home

Appendix 4: Notes on children with high blood lead levels

These notes describe the circumstances of each child whose blood lead level was greater than or equal to 0.73 µmol/L. Cases are discussed here in descending order of the children's blood lead concentration.

The notes include amounts and concentrations of lead in environmental samples from the children's homes. Because the collection methods used in this survey may not correspond exactly with those of other surveys, findings from a random sample of homes are summarised in Table 35 in the 'Results' section of this report.

As paint specimens were collected only from the 30% of homes where paint was in poor condition, the present data on lead levels in paint in Australian homes are very incomplete. Paint in poor condition is a risk factor for high blood lead level, and specimens were collected from 14 of the 25 (56%) homes of the 27 children described below. One of the 14 paint specimens was too small to be analysed. The laboratory reported 'The paint layers from any one flake ranged from 3 to 13 with an average of 7–8. The total thickness of the paint layers in the flakes ranged from 400 to 1500 microns with the individual paint layers ranging from 20–350 microns. Lead was found to occur mostly in the bottom 3 layers of a painted sequence ... Leaded paint layers ranged from 30–300 microns.'

Solubility of lead in paint specimens was measured for five residences where lead concentration in paint exceeded 10,000 mg/kg (1%).

Lead from different sources may be characterised by the variations in the relative abundance of its four isotopes. Where lead in a child's blood has come predominantly from one source, the relative abundance of these isotopes in blood and in the source is similar. Relative abundances are usually expressed as ratios $^{206}Pb/^{204}Pb$ and as $^{207}Pb/^{204}Pb$; the former varies more widely and is thus a better discriminant.

The $^{206}Pb/^{204}Pb$ ratio in leaded petrol has not been studied definitively, but it ranges from 16.4 to 16.5 in New South Wales and the Australian Capital Territory. In Queensland lead from a different source is used, and the ratio is in the range 17.6 to 17.8. Ratios for other States are not known (Gulson B 1995 pers. comm.). The notes identify the States of residence of the children as New South Wales or Queensland where relevant. For reasons of confidentiality, States of residence are not identified in other cases.

Case 1

The two youngest children of a large family were surveyed. The family had a low income, and was living in a 1925 (interviewer estimate) or 1910 (resident estimate) timber house in a rural area. Water was supplied by tanks which drained a metal roof. There were two old cars which used leaded petrol, there was a vegetable garden, and the family had both dogs and cats. People smoked in the house, which was rated by the interviewer as very dirty.

The elder child, aged 3 years, had a blood lead level of 0.51 µmol/L, and the younger child, aged 15 months, had a blood lead level of 1.58 µmol/L, the highest found. The only difference between answers regarding the children was that the elder child was described as never found eating soil, the younger as being found eating soil every day.

With parental permission, the State health authority was notified, and conducted its own tests for lead. Concentrations in water samples at four sites were all below 5 µg/L. Soil sampling near the front door yielded 22 mg/kg lead, the sandpit yielded 9 mg/kg lead, and roof gutter sludge yielded 155 mg/kg lead.

Survey environmental measurements, which became available only later, were 2.71 µg lead in the floor wipe tissue, 7.39 µg/L lead in water, 60 mg/kg lead in soil, and 952 mg/kg in paint. All measurements were at the upper ends of the respective distributions.

Both the $^{206}Pb/^{204}Pb$ ratio (18.93) and the $^{207}Pb/^{204}Pb$ (15.66) in the child's blood were the highest the CSIRO laboratory has found in Australian residents and substantially above the ratios in all the environmental specimens. Accounting for the isotopic composition of the blood requires a source with ratios at least as high as those in the blood. One such source would be soil not sampled by the survey; as this report was written there was no information on the geology of this part of Australia which might explain the findings. An alternative source would be materials made from lead mined in the United States.

The ratios in the floor wipes and in soil were closer than those in paint and in water, but still considerably different from those in blood.

Pending further examination of local soils, which is being arranged, it is considered likely that this child's very high blood lead level resulted primarily from eating soil, with contributions from many other risk factors.

Case 2

Both children in the family were surveyed. The family had an above-average income and was living in a 1920 (interviewer estimate) or 1912 (resident estimate) brick house on a major road in a capital city. The road carried 31,000 vehicles per day. The house was rated by the interviewer as very clean.

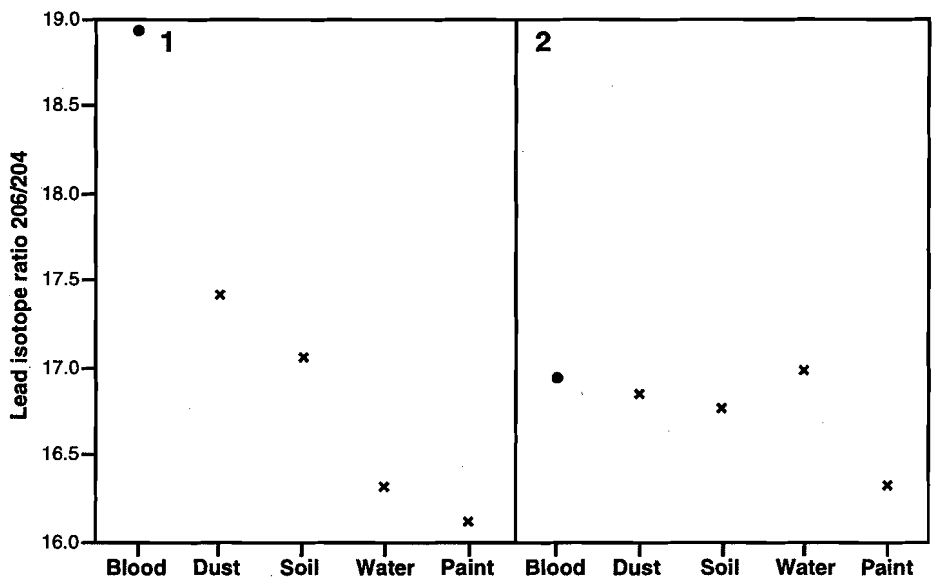
Interview information, later elaborated by the mother, was that the family car used unleaded petrol, there were two dogs which came indoors, and the parents occasionally used lead in hobbies, making stained glass or lead sinkers. The internal paintwork was rated as severe chalking or peeling; parts of the home had been renovated, but not recently, and the children's bedroom was one area that had not been renovated.

The elder child, aged 3.5 years, had a blood lead level of 0.49 µmol/L. The younger child, aged 21 months, had a blood lead level of 1.22 µmol/L. The elder child had no risk factors. The younger child was described as found eating soil more than once a week.

Environmental samples yielded 2.95 µg lead in the floor wipe tissue, 1.24 µg/L lead in water, 273 mg/kg lead in soil, and 139,000 mg/kg (13.9%) lead in paint. The high level in the floor wipe was despite the cleanliness of the house, and this indicates that the dust had a very high lead concentration, hence that paint was the source. The lead in the paint specimen was 65% soluble. However the $^{206}Pb/^{204}Pb$ ratio in paint (16.32) was substantially below that in the other environmental specimens (soil 16.76, water 16.99, dust wipe 16.85) and in the child's blood (16.94). The source of lead in the child's blood may thus have been soil or dust which contained soil. It may also have been paint other than that sampled, the location of which was not recorded by the interviewer.

Both the family and the family doctor responded very rapidly to notification. Although permission to notify the State health authority had not been given initially, it was supplied promptly.

Figure A1: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 1 and 2



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	1.58	2.71	60	7.39	952	1.22	2.95	273	1.24	139,000
Percentile	99%	95%	72%	84%	24%	99%	96%	92%	42%	95%

Case 3

An only child aged 13 months lived in a brick house built in 1985 (interviewer estimate) or 1982 (resident estimate) in a provincial city. The house was rated by the interviewer as very clean. There was some chalking or peeling of external paint. From 1992 until January 1995 the family had lived in a house built in 1900 in a capital city, and the parents had renovated that house during that time, including when the mother was pregnant and after the child was born. Internal paint there was described as showing severe chalking or peeling, and external paintwork as showing some chalking or peeling. The child sucked fingers or thumb and toys every day, and was found eating soil more than once a week.

The professional parents were well aware of the effects of lead, and on receipt of advice of the child's blood lead level of 1.20 µmol/L, had themselves tested, to discover that their blood lead levels were 0.2 and 0.3 µmol/L.

They also arranged for the child to see a paediatrician, who arranged testing for iron status as well, to discover the child was iron-deficient (haematocrit in the study specimen was 40). Some dietary changes were made.

The child's blood lead level was measured again 10 weeks after the survey, as 0.8 µmol/L.

Environmental sampling results were:

dust wipe	0.06 µg lead
water	1.56 µg/L lead

The paint specimen was insufficient for analysis, and the soil specimen appears to have been lost, but as the exposure to lead almost certainly occurred in the previous home, this was not pursued.

Case 4

The 2.5-year-old youngest child in a large, low-income family was surveyed. The family lived in a rented fibro-cement house built in 1960 (interviewer estimate) or 1955 (resident estimate) in what had been agricultural land on the outskirts of Sydney. There was some peeling of internal paint, but none externally. There was a pet dog, and people smoked inside the house. The interviewer rated the house as very dirty.

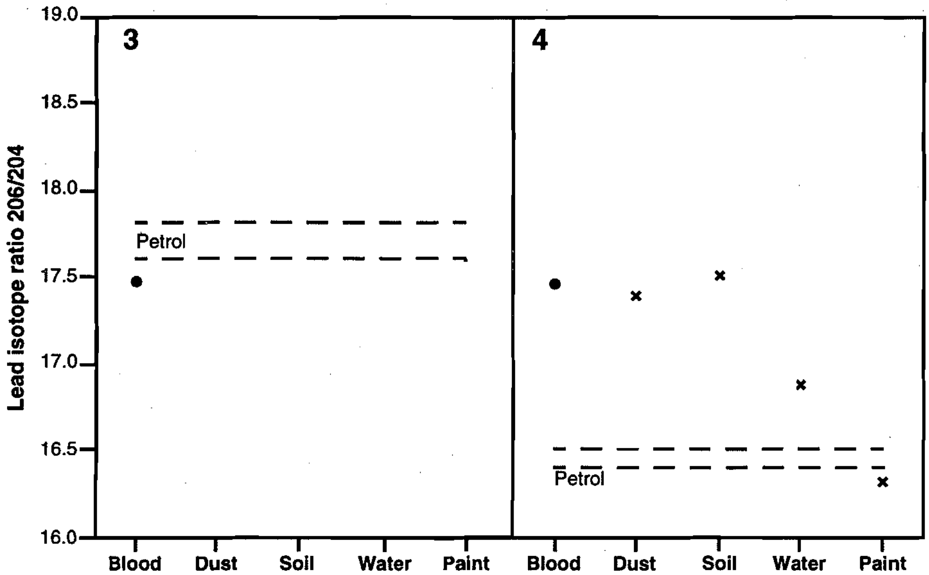
The child had a blood lead level of 1.20 µmol/L. The only apparent risk factor pertaining to the child was being found eating soil every day.

The lead levels in dust (1.42 µg), paint (25,000 mg/kg) and soil (221 mg/kg) were all high. The lead in the paint specimen was 55% soluble. Lead in water (1.84 µg/L) was normal. $^{206}Pb/^{204}Pb$ ratios were similar in blood (17.46), dust wipe (17.38) and soil (17.50), and much higher than in paint (16.32) and in water (16.87).

The source of the lead appears to have been soil.

Permission to notify the State health authority was not given at interview, but the mother telephoned the Institute on receipt of advice of the lead level. The condition of the paint was discussed, and because there might have been an obligation on the part of the public housing authority, it was suggested the State health authority be notified. Written permission to do this was requested and promised, but was never received.

Figure A2: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 3 and 4



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	1.20	0.06	missing	1.56	not sufficient	1.20	1.42	221	1.84	24,862
Percentile	99%	10%		49%		99%	93%	90%	56%	80%

Case 5

The elder two of three children of parents who migrated to Australia during the 1980s were included in the survey. The family rented a brick house built in 1928 (interviewer estimate) or 1915 (resident estimate) in a middle-distance suburb of Sydney. The house, into which they moved in January 1995, was rated as dirtier than average but there were no obvious problems with paintwork. The family had lived at the previous address for a short period only. They had one car which used leaded fuel.

The eldest child, aged 4 years, had a blood lead level of 0.59 µmol/L, and no personal risk factors. The second child, aged just over 2 years, had a blood lead level of 1.18 µmol/L. This child was described as found eating soil less than once a week.

The lead level in water was notably high at 42.14 µg/L. Lead levels in dust (0.61 µg) and soil (101 mg/kg) were in the highest quartile. There was no paint specimen. $^{206}Pb/^{204}Pb$ ratios were similar in blood (16.74), dust (16.78) and soil (16.61), and the ratio in water (16.11) was much lower.

Because of the short time the family had spent at the current address, the source of the high lead level cannot be identified with certainty. With parental permission, the case was notified to the State health authority.

Case 6

Both children in a low-income family living in a brick semi-detached house on a major road in an inner suburb of Sydney were included in the survey. The traffic count was 44,000 vehicles per day.

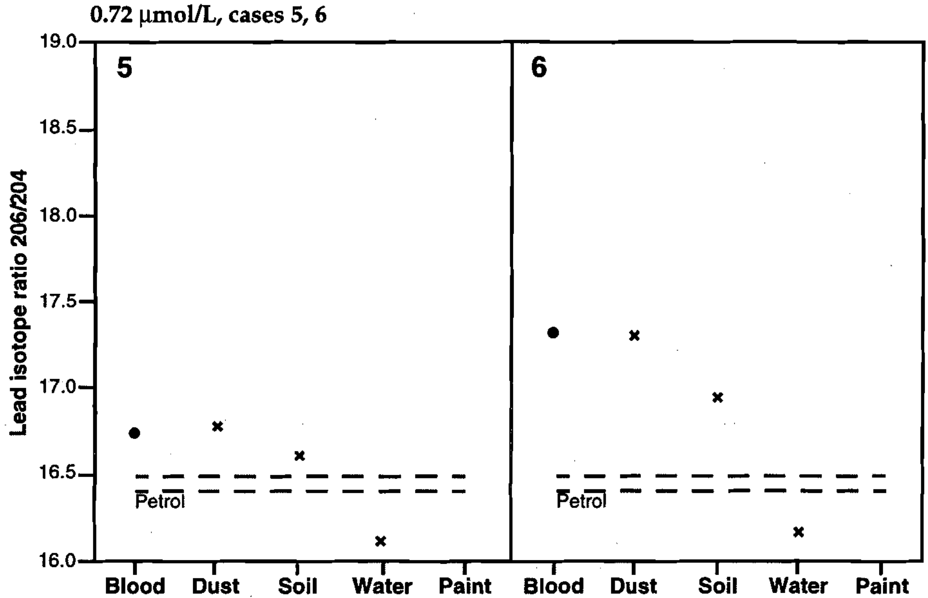
The interviewer estimated that the house had been built in 1920, the resident gave 1930. The house was rated as dirtier than average, and there was some chalking or peeling of interior paint only. There had been some renovations but the children had not lived at the house during them. The family had a pet dog.

The elder child, aged 4.5 years, became upset and no blood specimen was taken. The younger child, aged 3, had a blood lead level of 1.09 µmol/L. This child sucked fingers and thumb and toys but less than once a week.

Environmental sampling yielded dust wipe 3.82 µg lead, soil lead 1102 mg/kg, and water lead 17.8 µg/L, all values being high but not indicating a single source of lead. There was no paint specimen. $^{206}Pb/^{204}Pb$ ratios in blood (17.32) and in dust wipe (17.31) were very close, and much higher than those in soil (16.94) and in water (16.16). Dust appears to be the immediate source of the lead in the child's blood, but its ultimate source is uncertain.

The State health authority was notified.

Figure A3: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 5, 6



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/ kg	mg/L	mg/kg
Reading	1.18	0.61	101	42.14	no peeling	1.09	3.82	1,102	17.8	not collect-able
Percentile	99%	81%	82%	99%		99%	97%	97%	95%	

Case 7

Two immigrant families shared a house on the intersection of two major roads with traffic counts of 20,000 and 24,000 vehicles per day in an inner suburb of Sydney. One family had a young child. The house was built in 1910 (interviewer estimate) or 1895 (resident estimate). There was little external paintwork; the internal paint was described as showing severe chalking or peeling. Cleanliness was rated as average.

The interview was conducted through an interpreter. The 1-year-old child was stated as having no risk factors except eating soil less than once a week. The blood lead level was 1.02 µmol/L.

Permission to notify the State health authority was not obtained at interview. As the letter advising the family of the blood test results was in English, follow-up was arranged through an interpreter service, but nothing more was heard.

Lead measurement in environmental samples did not disclose a source of the child's high blood lead level. They were:

dust sample	0.61 µg lead
water lead	6.79 µg/L
soil lead	1,325 mg/kg
lead in paint	693 mg/kg.

Isotopic studies showed the $^{206}Pb/^{204}Pb$ ratio in blood as 16.88. This was close to the value of 16.92 in the dust wipe, but some distance from the values of 16.34 in paint, 17.10 in water, and 17.34 in soil. The source of the lead in the dust remains undetermined.

Case 8

A very large family, the sixth and seventh children of which were included in the survey, had lived in a fibro-cement house in a provincial city since December 1994. For the preceding eight months they had lived in a 1980 home with paintwork in good condition.

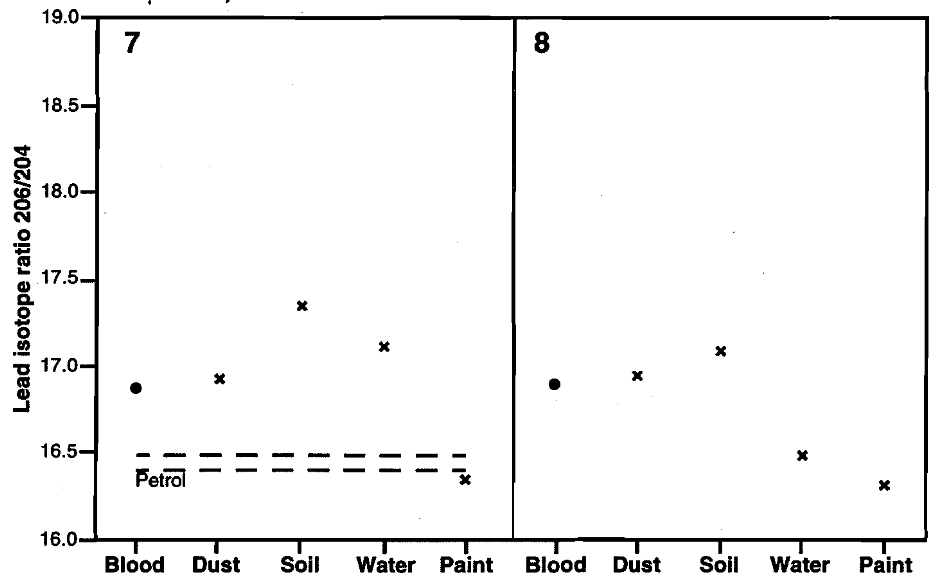
The present house was built in 1965 (interviewer estimate) or 1970 (resident estimate). In the home there was some chalking or peeling of internal paintwork. There were two cars which used leaded fuel, and there was a pet dog. Cleanliness was rated as average.

The sixth child, aged 3.5 years, had a blood lead level of 0.68 µmol/L. This child did not have any personal risk factors. The seventh child, aged 2 years, had a blood lead level of 1.01 µmol/L. This child was described as being found eating soil every day.

Lead in the dust wipe (0.67 µg), and its levels in water (8.47 µg/L) and soil (78 mg/kg) were all in the highest quartile, but these values do not point to any single source. Lead in a paint sample was 994 mg/kg. The $^{206}Pb/^{204}Pb$ isotope ratios in blood (16.88) and dust wipe (16.94) were similar, and much higher than those in water and paint, but lower than that in soil (17.09).

With parental permission, the State health authority was notified.

Figure A4: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 7 and 8



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	1.02	0.61	1,325	6.79	693	1.01	0.67	78	8.47	994
Percentile	99%	81%	98%	83%	20%	99%	84%	77%	87%	25%

Case 9

A family with one child living in an outer suburb of a capital city was surveyed. They had lived in their brick house, built in 1985 (interviewer estimate) or 1986 (resident estimate) since July 1994. Survey documents describe the house as having no interior or exterior paintwork. The family used tank water for drinking and cooking. The roof was tiled. The home was rated cleaner than average.

The 18-month-old child had a blood lead level of 0.97 µmol/L. The child was described as sucking toys every day and being found eating soil more than once a week.

Environmental lead findings reflect the recent construction of the house. Lead in the dust wipe was 0.24 µg, in tank water the level was 2.28 µg/L, and in soil it was 3 mg/kg. The $^{206}Pb/^{204}Pb$ isotope ratio in blood (17.98) was unusually high, higher than in soil (17.70), and much higher than in the dust wipe (16.98) and in water (16.87). There was no paint specimen. No risk factors were apparent, and as permission to notify was not given, the source of the high blood lead level remains unidentified.

Case 10

The youngest two of four children from a family which lived in a small village on a country road were included in the survey. The interviewer assessed the road as major, but the traffic count was only 2,100 vehicles per day.

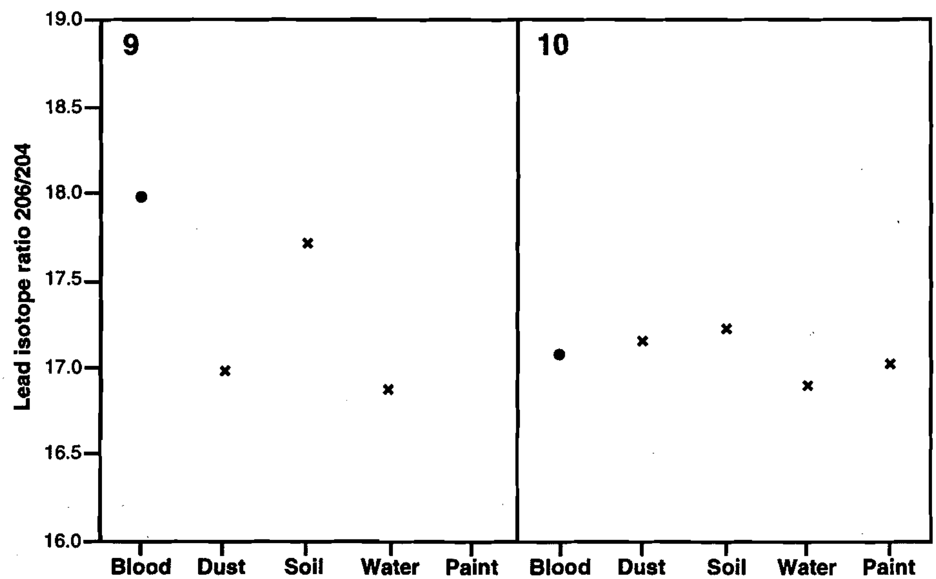
Water was piped some distance from a town. Their timber house was estimated as built in 1960 (interviewer estimate) or 1945 (resident estimate). There was some peeling of both internal and external paint. There had been some renovation within the previous 12 months and the children had continued to live in the house during that time. The house was rated as of average cleanliness. Two vehicles owned by the family used leaded petrol.

The third child, aged just under 3 years, had a blood lead level of 0.55 µmol/L. This child was described as sucking her thumb more than once a week. The fourth child, aged just under 2 years, had a blood lead level of 0.97 µmol/L. This child sucked his fingers and thumb less than once a week. Both children were described as sucking or chewing toys, and eating dirt, every day.

In this household, floor dust (0.93 µg) and soil (255 mg/kg) lead findings were comparatively high. A paint sample yielded 196,000 mg/kg (19.6%) lead, 77% soluble. The lead concentration in water (3.14 µg/L) was unremarkable. The $^{206}Pb/^{204}Pb$ ratio in the paint sample was 17.02, close to that in blood (17.07). Paint is thus the likely source of the high blood lead level.

With parental permission, the State health authority was notified.

Figure A5: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 9 and 10



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.97	0.24	3	2.28	no paint work	0.97	0.93	255	3.14	196,078
Percentile	99%	50%	5%	61%		99%	89%	92%	71%	96%

Case 11

Two children in a large family in Broken Hill were included in the survey. They lived in a brick house built in 1950 (both estimates) with some chalking or peeling of external paintwork but no chalking or peeling internally. The house was described as cleaner than average. There were several occupational and hobby risk factors, and there had been renovation within the past 12 months.

A 4-year-old child had a blood lead level of 0.92 µmol/L, as measured for the Broken Hill Environmental Lead Centre. A 2.5-year-old child had a blood lead level of 0.87 µmol/L, similarly measured. Both children sucked toys but had no other personal risk factors.

The floor wipe yielded 1.43 µg lead in house dust, and soil lead was 88 mg/kg. The lead concentration in water was 0.38 µg/L, and comparatively low. These specimens were lost before they could be tested for lead isotope composition. The paint specimen was unsuitable for analysis, as it turned out to consist mainly of unpainted brick.

In both children the high blood lead levels appear to be related to the Broken Hill environment generally. Permission to notify the New South Wales Health Department was not given, but as the findings were already known to the Broken Hill Environmental Lead Centre, this did not need to be pursued.

Case 12

A family with one child aged 2 years and 9 months lived in a timber house built in 1965 (interviewer estimate) or 1960 (resident estimate) in Brisbane. There were several occupational risk factors, there was a pet dog, and there had been home renovations since the family moved there in September 1994. The house was described as of average cleanliness.

The child, who had a blood lead level of 0.92 µmol/L, had lived at the house during the renovations, and was also cared for at a place with severe chalking or peeling of both interior and exterior paint. He sucked toys more than once a week, and was found eating soil less than once a week.

House dust lead was very high at 2.0 µg on the wipe. Water lead was also high at 26.71 µg/L. In contrast, soil lead was relatively low, at 29 mg/kg. A paint flake yielded 3,296 mg/kg lead. However, the $^{206}Pb/^{204}Pb$ ratio in this paint specimen was 16.12, well below the ratio of 16.59 in the child's blood. Renovations may explain the high lead level, and it is possible that the paint sample was not representative. Peeling paint at the place where the child was cared for is another possible source, but there are no specimens to show this. The low isotope ratio in blood of 16.59 is not compatible with a contribution from lead in Brisbane petrol.

The family moved to another home one week after interview but follow-up was possible because the State health authority had, with parental permission, been notified.

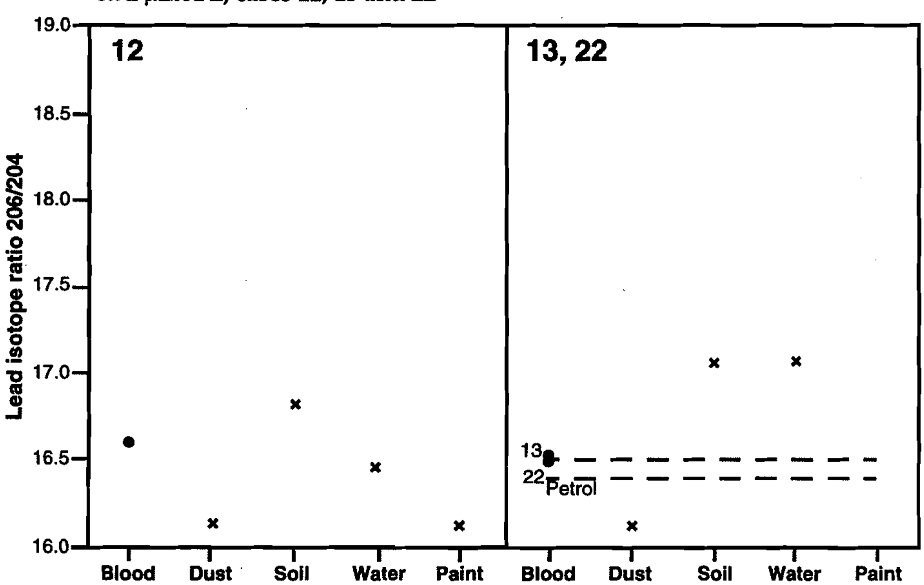
Case 13

Both children in the family were included. The family lived in a brick house built in 1920 (interviewer estimate) or 1914 (resident estimate) in an inner suburb of Sydney. The house had recently been renovated, and one of the parents also painted china as a hobby, although not at the home. There were no pets, and only a small vegetable garden. No history of risk factors was obtained for either child.

The elder child, aged 3, had a blood lead level of 0.91 µmol/L, and the 15-month-old second child had a blood lead level of 0.75 µmol/L. The parents responded rapidly to advice of the blood lead levels and accepted that renovation was the most likely cause of the high readings.

Environmental sample results became available only later. The dust wipe gathered 19.37 µg lead, a very high amount. Lead in soil was 163 mg/kg and in water was 5.89 µg/L. No paint sample was collected. The two children had similar $^{206}Pb/^{204}Pb$ ratios in blood of 16.52 and 16.49, but these ratios were very different from those in the dust wipe (16.13, a low reading in this city) and in soil and water (both 17.07). The isotope ratios in blood suggest a mixed contribution from lead in soil and in dust, some of the latter lead having originated in petrol.

Figure A6: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 12, 13 and 22



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.92	22.09	29	26.71	3,296	0.91 0.75	19.37	163	5.89	no peeling
Percentile	99%	99%	57%	98%	54%	99% 98%	99%	87%	81%	

Case 14

See Case 11.

Case 15

A 1-year-old child living in the outer suburbs of a capital city was included in the survey. The rented brick house built in 1955 (interviewer estimate) or 1960 (parent) had some chalking or peeling of internal paint, and severe chalking or peeling of external paint. Some renovation had been done while the child lived there. The house was rated as of average cleanliness.

The child sucked or chewed his toys every day, and was found eating soil more than once a week. His blood lead level was 0.82 µmol/L. The household dust sample yielded 0.37 µg lead, lead in soil was 165 mg/kg, and in water was 1.59 µg/L. The lead concentration in paint was 54,124 mg/kg, and soluble lead was 56,364 mg/kg in another part of the specimen; that is, all the lead may have been soluble. The $^{206}Pb/^{204}Pb$ ratio in lead on the dust wipe was 16.73, close to but still below the 16.82 ratio in the child's blood. Ratios in soil (16.41), water (16.34) and paint (16.04) were much lower.

Both the State health authority and the family doctor were notified of the findings.

Case 16

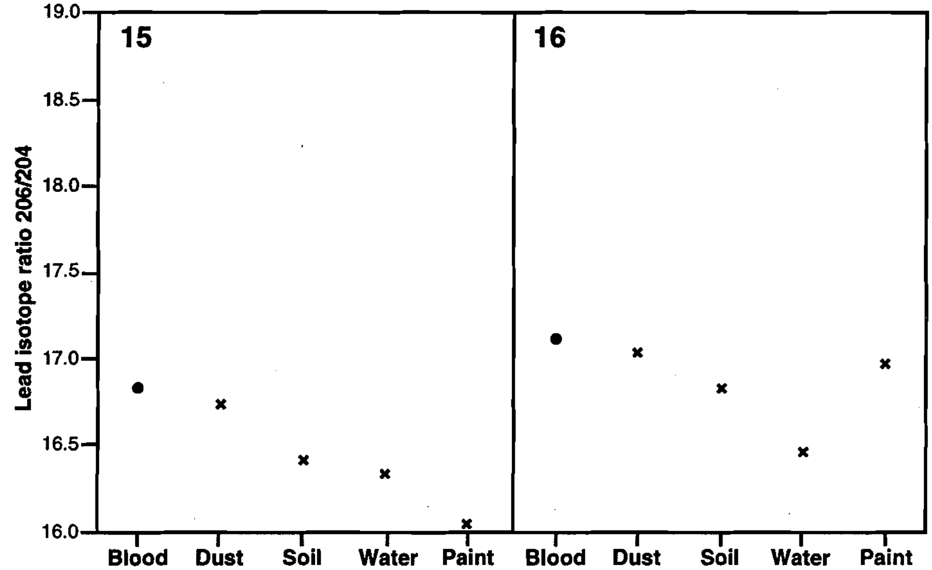
An only child living in a timber house in an inner suburb of a city was included in the survey. The family had moved there in April 1994. The house, rated as dirtier than average, was assessed by the interviewer as having been built in 1950 and by the family as having been built in 1930. The interior paint was rated as showing severe chalking and/or peeling and the exterior paint as showing some chalking and/or peeling. Automotive repairs was listed as a hobby of the adult occupants, and the family car used leaded petrol.

The 2-year-old child had a blood lead level of 0.80 µmol/L. She was described as sucking her thumb less than once a week and her toys every day. There were no other risk factors relating to her.

The dust wipe yielded 0.68 µg lead. Lead concentrations were 462 mg/kg in soil, 2.19 µg/L in water, and 194 mg/kg in paint. The $^{206}Pb/^{204}Pb$ ratio in the dust wipe (17.03) was close to that in the child's blood (17.11). Ratios in soil and in water were much lower.

Permission was given to notify the family doctor but not the State health authority.

Figure A7: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 15 and 16



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.82	0.37	165	1.59	54,124	0.80	0.68	462	2.19	194
Percentile	99%	65%	88%	50%	85%	98%	84%	95%	60%	10%

Case 17

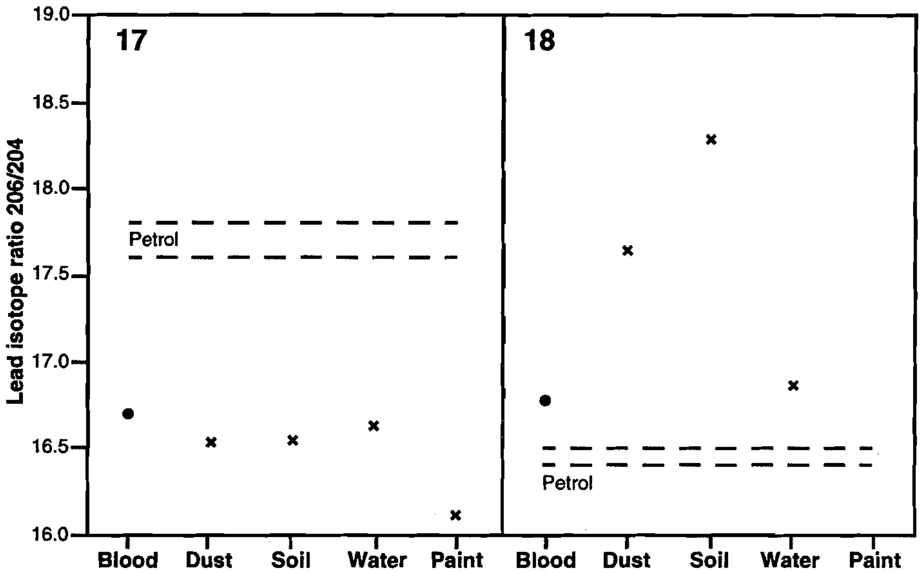
The younger of two children of a family living in a timber house in a southern Queensland township was included in the survey. The house was estimated by the interviewer to have been built in 1900; the residents' estimate was 1910. There was chalking and/or peeling of the exterior paint only. There had been renovation in the last 12 months and the children had lived there during that time. House cleanliness was assessed as average.

The father worked in automotive repair.

The child, aged 1.5 years, sucked his fingers or thumb and his toys every day. His blood lead level was 0.78 µmol/L. The sample of floor dust yielded 0.78 µg lead. The lead levels in soil (1,261 mg/kg) and water (8.45 µg/L) were also not especially high. The lead concentration in paint was 18,519 mg/kg, of which 78% was soluble. The $^{206}Pb/^{204}Pb$ ratio in blood was 16.70. This was a little higher than those in water (16.63), soil (16.54) and in the dust wipe (16.53), but well above that in the paint specimen (16.11). A possible explanation is that the lead came predominantly from water, soil or dust, with a contribution from Queensland petrol.

The State health authority was notified.

Figure A8: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 17 and 18



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.78	0.89	1,261	8.45	18,519	0.77	0.16	9	3.61	no peeling
Percentile	98%	88%	97%	87%	78%	98%	32%	25%	74%	

Case 18

All three children in a low-income family living since 1993 in a newly built home in a newly developed and previously rural area of a provincial New South Wales city were included in the survey. The interviewer rated the house as cleaner than average. There was one car which used leaded petrol.

The 4.5-year-old eldest child had a blood lead level of 0.14 µmol/L, and the 3.5-year-old second child had a blood lead level of 0.24 µmol/L, but the 14-month-old youngest child had a blood lead level of 0.77 µmol/L. The youngest child had been found eating soil, but less than once a week.

The family doctor responded to the notification. It was agreed that the history did not indicate any obvious source of lead. On being informed that authority to notify the State health authority had not been given, he volunteered to approach the parents and the authority. He does not appear to have done so.

The environmental specimens became available later. The dust wipe yielded 0.16 µg lead, the soil specimen 9 mg/kg lead, and the water specimen 3.61 µg/L lead. The $^{206}Pb/^{204}Pb$ ratio in the child's blood was 16.77. This was close to the ratio in water (16.86) but well below those in the dust wipe (17.64) and in soil (18.28).

Because of the great differences in blood lead levels within the family, and the low environmental levels, the lead measurements were repeated on leftover whole blood.

The result (from Royal Prince Alfred Hospital) was 0.69 µmol/L. It remains possible that this specimen was contaminated at the time of collection, but it was not possible for the survey to arrange collection of a second blood specimen from the child to check this possibility.

Case 19

The 2.5-year-old second of three children in a family was included; the youngest child was aged 8 months. The family lived in a large country town, in a house built in 1978 (interviewer estimate) or 1973 (resident estimate). There were two family vehicles; both used leaded petrol. Parents smoked, there were pet cats and dogs, and there was a vegetable garden. The house was of average cleanliness. No risk factors relating to the child were identified at interview.

The child had a blood lead level of 0.76 µmol/L. With parental permission this was notified to the State health authority, which sent a scientific officer to investigate. The mother then initiated contact with the Institute.

These discussions revealed that the home was next door to a disused drive-in theatre. The scientific officer thought this was not a likely source of lead.

The father was an electrician who worked for a fertiliser manufacturing company which did handle lead products. Although there was no proof that he handled lead in his work, it was suggested by the scientific officer that his work clothes be washed away from the home.

The scientific officer also learnt from the mother that all three children frequently visited grandparents who were renovating their home. This was viewed as another possible source of lead.

Four children from the property next door were included in the survey. Their blood lead levels ranged from 0.30 to 0.45 µmol/L.

Environmental lead results were:

dust sample	0.85 µg lead
soil sample	51 mg/kg lead
water sample	118.80 µg/L lead

When questioned about household plumbing, the mother reported that a new mixer tap had been only recently installed at the time of the survey.

There was no paint specimen. The $^{206}Pb/^{204}Pb$ isotope ratio in blood (16.86) was close to that in the dust wipe (16.75) but much higher than those in water (16.56) and in soil (16.49). The ultimate source of the lead in the dust is not apparent.

Case 20

The youngest two of three children in a family were included in the survey. The home had been built in 1993 (both estimates) on what had formerly been a rifle range, on the outskirts of a capital city. Some repainting had been done since occupation, but that should not have influenced lead levels in the children, who had lived there during this time. There were no other risk factors relating to the household, which was recorded as of average cleanliness.

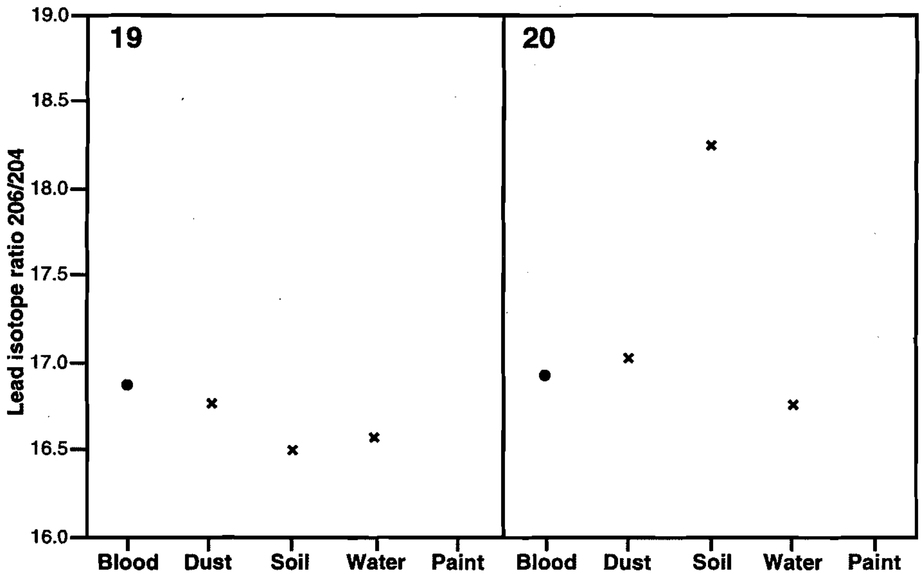
The elder child studied, aged 4.5 years, had a blood lead level of 0.76 µmol/L. This child was a thumb-sucker, but no other risk factors were identified at interview. No specimen was obtained from the youngest child, aged 2.5 years.

There was 0.41 µg lead in the dust wipe. Concentrations of lead in soil were 3 mg/kg and in water 16.21 µg/L. No paint sample was taken. The $^{206}Pb/^{204}Pb$ isotope ratio in the child's blood (16.92) was close to that in the dust wipe (17.02) and only a little different from that in water (16.75), but very different from that in soil (18.24).

The source of the high blood lead level is dust, but the ultimate source of the lead is not apparent from this information.

Permission to notify the State health authority was not given.

Figure A9: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 19 and 20



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.76	0.85	51	118.8	no peeling	0.76	0.41	3	16.21	no peeling
Percentile	98%	88%	69%	99%		98%	68%	5%	95%	

Case 21

Until December 1994, a single-child low-income family had lived in a home built in 1960 with some chalking or peeling of internal paintwork. They had then moved to a 1960 (both estimates) weatherboard house in the outer suburbs of Sydney. This house had no problems with the internal paintwork but some chalking or peeling of external paintwork. Cleanliness was assessed as average. There were five vehicles, four of which used unleaded petrol, and automotive repair and panel beating were listed as both occupational and hobby exposures.

There were no risk factors relating to the child, who was 18 months old at the time of the survey. The blood lead level was 0.76 µmol/L.

The dust wipe yielded 0.35 µg lead. Concentrations of lead in soil (121 mg/kg) in water (3.57 µg/L) and in paint (2,745 mg/kg) were not notably high. The $^{206}Pb/^{204}Pb$ ratio in the child's blood was 16.86. This was close to that in the dust wipe (16.76). Ratios in soil (16.52) and paint (16.19) were lower. In the water specimen the ratio was much higher (18.20).

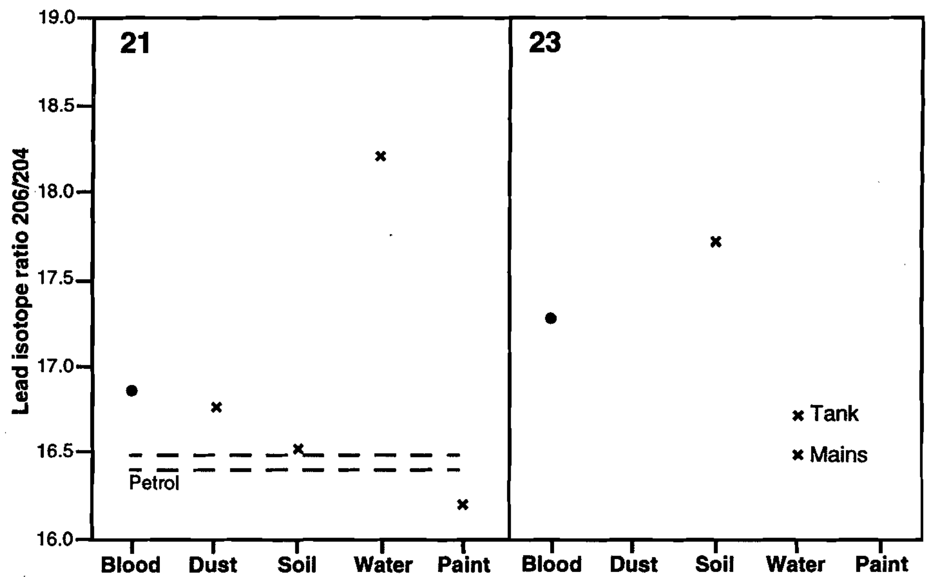
The source of the high blood lead level is dust.

The family doctor was notified but permission to notify the State health authority was not given.

Case 22

See Case 13.

Figure A10: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 21 and 23



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.76	0.35	121	3.57	2,745	0.75	25.07	1,024	2.37 76.27	no peeling
Percentile	98%	64%	85%	74%	49%	98%	99%	97%	63% 99%	

Case 23

Until January 1995, a single-child family had lived in a 1988 home. They then moved to a 1958 brick house (both estimates) in a country town. As well as using town water, the household used tank water collected from a metal roof. Parental hobbies were said to include home renovation (but none had been done at either home), staining glass, and panel beating or spray painting (neither of the two vehicles used leaded petrol). The house was rated as very dirty.

The 3.5-year-old child had no risk factors. His blood lead level was 0.75 μmol/L.

The dust wipe yielded 25.07 μg lead, the highest obtained at time of writing. Soil lead was high at 1,024 mg/kg, but there was no paint specimen. The mains water yielded 76.27 μg/L lead, but rainwater only 2.37 μg/L lead. The $^{206}Pb/^{204}Pb$ ratios were 16.48 in tank water, 16.70 in mains water, 17.27 in the child's blood and 17.70 in soil. The lead in the child's blood seems to have come from more than one source.

Both family doctor and the State health authority were notified.

Case 24

All three children of a family were included in the survey. They lived with a relative in a 1980 (both estimates) brick house in a large country town in New South Wales. The house was rated as dirtier than average. The one vehicle used leaded petrol, and there were smokers in the household.

The 4-year-old eldest child had no risk factors but was not at home at time of collection. The 3-year-old second child sucked fingers and thumb, and also toys, less than once a week, and had a blood lead level of 0.62 μmol/L. The 18-month-old youngest child sucked fingers and thumb, and also toys, more than once a week, and had a blood lead level of 0.75 μmol/L.

Environmental testing found 0.53 μg lead on the floor wipe, 28 mg/kg lead in soil and 14.63 μg/L lead in water. There was no paint specimen. The $^{206}Pb/^{204}Pb$ isotope ratio in blood was 16.95, higher than the 16.37 in water, but less than the 17.15 in the dust wipe and much less than the 17.91 in soil. Again a mixture of sources is suggested.

Permission to notify the State health authority was not given.

Case 25

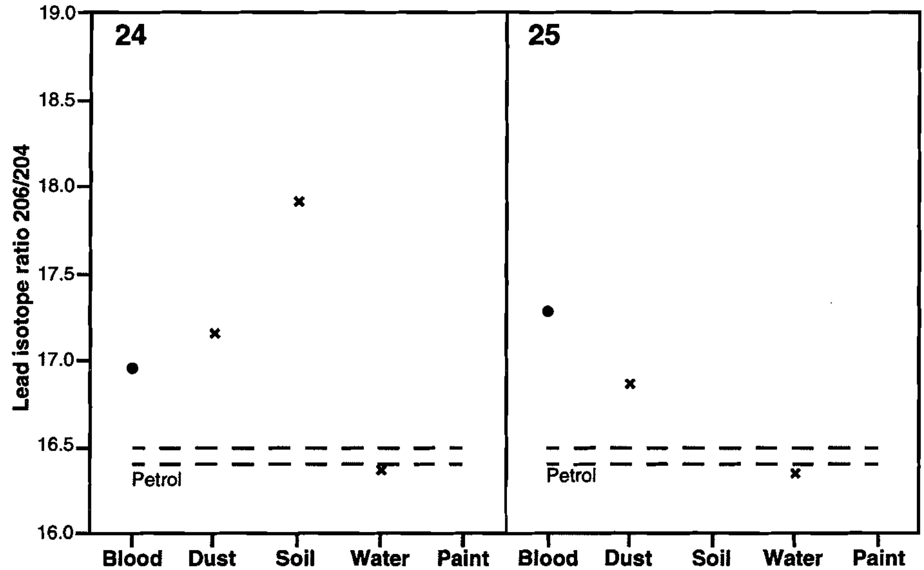
A 4.5-year-old only child lived with his parents in a three-storey block of flats on a major road (traffic count not available) in the middle suburbs of Sydney. One parent was a recent migrant from South-East Asia. The brick building with no external paintwork was estimated to have been built in 1970 (interviewer) or 1965 (resident). There was some chalking or peeling of internal paint. The flat was rated as cleaner than average.

The child was said to suck fingers or thumb, and toys, every day, and to be found eating soil every day. The blood lead level was 0.74 μmol/L.

The house dust wipe yielded 0.94 μg lead. The concentration of lead in water was 7.43 μg/L and in a paint flake was 186 mg/kg. No soil specimen was collected. The $^{206}Pb/^{204}Pb$ ratio was 17.27 in the child's blood, 16.85 in the dust wipe and 16.33 in water. Neither dust nor water can be major contributors to the blood lead.

The State health authority was notified.

Figure A11: Lead levels for households of children with blood lead concentration above 0.72 µmol/L, cases 24 and 25



Units	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg	µmol/L	µg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.75	0.53	28	14.63	no	0.74	0.94	flat—	7.43	186
Percentile	98%	76%	56%	94%	peeling	98%	90%	no soil	84%	9%

Case 26

A 3-year-old child lived with his Middle-Eastern immigrant parents and two much older siblings in a middle suburb of Sydney. The parents and the oldest child had arrived in Australia 20 years ago. The fibro-cement house was estimated to have been built in 1935 (interviewer) or 1922 (resident). The house was rated as cleaner than average, and the internal paint was in good condition. There was no external paint. There were smokers in the household.

There were no risk factors relating to the child, whose blood lead level was 0.73 µmol/L.

The house dust wipe yielded 0.73 µg lead. The soil lead concentration was 1,778 mg/kg, and the water concentration 8.67 µg/L. There was no paint specimen. The $^{206}Pb/^{204}Pb$ ratio in the child's blood (16.33) was the same as in the water specimen and very close to that in one soil specimen (16.31). It was also within the range found in petrol. Ratios in the dust wipe (16.67) and in another soil specimen (16.09) were very different. Soil and/or petrol appear to be the major contributors to the lead in blood.

The State health authority was notified.

Case 27

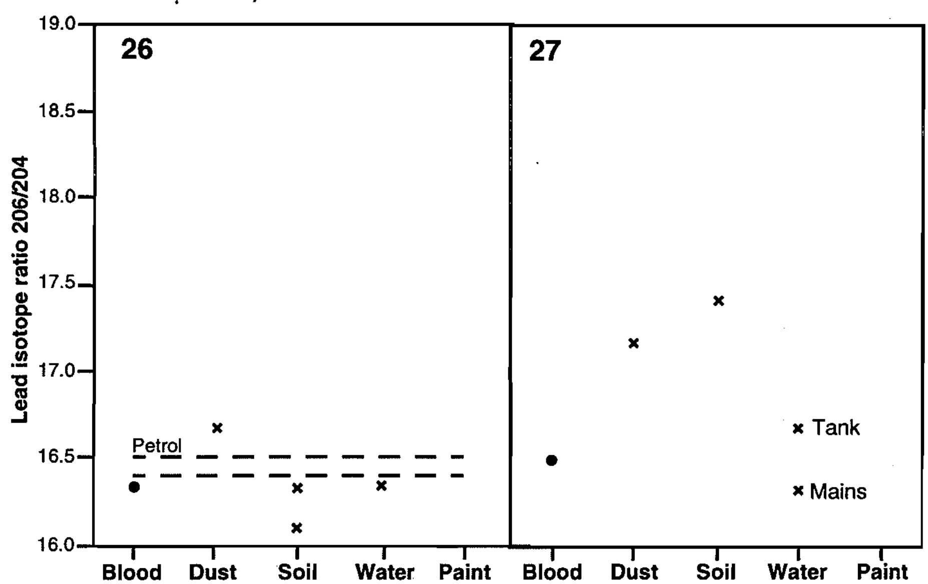
Both children of a family living in a brick house in a small country town were included in the survey. The house was built in 1975 (both estimates), all paint was in good condition, and cleanliness was rated as average. As well as town water, the family used tank water collected from a metal roof. Hobbies included automotive repairs and making sinkers for fishing. The house was on a main road which had been a major highway before the town was bypassed. No current or previous traffic count was available.

The elder child, aged 3.5 years, sucked fingers or thumb every day, and was found eating soil less than once a week. The blood lead level was 0.73 μmol/L. The younger child, aged 21 months, sucked fingers or thumb every day, and was found eating soil more than once a week. The blood lead level was 0.29 μmol/L.

There was 0.13 μg lead on the dust wipe, 22 mg/kg lead in soil, 6.38 μg/L in mains water and 3.14 μg/L in tank water. The $^{206}Pb/^{204}Pb$ ratio in the blood from the elder child was 16.50, between those in town water (16.32) and in tank water (16.68). The ratios in the dust wipe (17.16) and in soil (17.42) were much higher. No individual sample accounts for the elevated blood lead in this child. A contribution from lead in petrol has to be considered.

Both family doctor and State health authority were notified.

Figure A12: Lead levels for households of children with blood lead concentration above 0.72 μmol/L, cases 26 and 27



Units	μmol/L	μg/ wipe	mg/kg	mg/L	mg/kg	μmol/L	μg/ wipe	mg/kg	mg/L	mg/kg
Reading	0.73	0.15	1,778 3,850	8.67	no peeling	0.73	0.13	22	3.14 6.38	no peeling
Percentile	98%	29%	99%	87%		98%	25%	51%	71% 82%	

Appendix 5: Details of sampling and estimation

Classification of census districts

Census Collector Districts (CDs) were classified as non-remote or remote using the Australian Standard Geographic Classification definition of Section of State (SOS) as follows:

0. Major urban: all urban centres with a population of 100,000 and over.
1. Other urban: all urban centres with a population of 1,000 to 99,999.
2. Bounded locality: all localities with a population of 200 to 999.
3. Rural balance: the remainder of the State or Territory.
4. Migratory: off-shore areas and migratory.

All CDs in SOS categories 0, 1 and 2 were classified as non-remote. So were CDs in category 3 which are also in Capital City Statistical Divisions. CDs in SOS category 3, but not in Capital City Statistical Divisions, were classified as remote. The SOS category 4 contains mainly people who are in transit and was regarded as being out-of-scope for this survey.

Sample design constraints

The sample design chosen was area-based, with randomly selected CDs. In remote areas, for logistic reasons, whole CDs were to be surveyed, with a sampling fraction of 1 in 250 (0.4%). In other areas, one-third of each sampled CD was to be surveyed, so the sampling fraction required was 3 in 250 (1.2%).

To ensure availability of interviewers outside major centres, the CDs selected needed to be geographically related to the CDs currently used in the ABS Labour Force Survey (LFS), for which ABS already had contracted with local interviewers.

To avoid problems of respondent burden or any other interference with the LFS, ABS wished the survey to avoid CDs currently in the LFS or likely to be in it in the near future.

Sampling for the Labour Force Survey

It is necessary to outline the complex process of CD selection for the Labour Force Survey (LFS). Regions within each State and Territory are split up into a number of strata which cover the whole State without any overlap. Each stratum is made up of a number of CDs with approximately 300 dwellings in each. Each CD is divided into clusters of between six and eight dwellings, and the number of clusters in each CD is known.

The CDs within each stratum are sorted in geographic serpentine order, that is starting in the north-east corner of the stratum, moving west until the boundary is met, then south to the next CD below and moving east until the border is met, and so on.

The number of clusters to be sampled within any State is determined. Then the sample of CDs is selected from a random start, by moving forward in the list of CDs by the appropriate number of clusters. The probability of selecting a CD thus depends on the number of dwellings in the CD and the State sampling fraction.

In sparsely settled areas, an extra stage of selection is used. Each stratum is split up into Primary Selection Units (PSUs) each consisting of a number of geographically close CDs. The number of CDs in a PSU varies across States and regions, and in some cases all the CDs in a single PSU could potentially be in the LFS sample.

Where a CD is selected by LFS and is in a PSU, the CD one behind and eligible for the National Survey of Lead in Children (NSLC) frame would usually also be in the same PSU. As many of the PSUs had the majority of CDs selected by LFS, it was decided that the CD behind could come from a different PSU.

Selection of current survey sample

The stratification used was based on operational requirements and not intended to yield estimates at the 'remote' level.

The CDs used in any LFS survey vary in a regular fashion. So that CDs in the LFS would not be not affected by this survey, it was decided to restrict the frame of CDs for this survey to those one behind (in the opposite direction to which the LFS rotation occurs) each LFS CD, unless that CD itself was also in the LFS. In this way, a CD chosen for the present survey could not currently be selected in the LFS, and would not be rotated into it in the near future.

The sampling strategy for the LFS also differs from that of this survey. CDs are selected for the LFS with likelihood in proportion to their population, taking into account which State or Territory they are in. The LFS is designed to provide State estimates as well as national estimates and hence the sampling fractions vary from State to State. There were 3,668 eligible CDs identified in the stratum of 24,593 non-remote CDs. Before CDs were chosen from this frame, the unequal probability of selection of CDs for the LFS was reversed (see below). All eligible CDs thus had an equal chance of selection, and 296 (1.20%) of them were selected for the survey.

Similarly, there were 376 eligible CDs identified in the stratum of 3,080 remote CDs; 13 of them (0.42%) were selected for the survey.

It was later discovered that the 433 CDs in Hobart, in Darwin, and in the growth areas of the Australian Capital Territory were incorrectly included in the population of 24,593 CDs used to calculate the number of non-remote CDs to be sampled. The number of CDs in this stratum should have been 24,160, and the sample should have been 290, or 2% less than that identified. Interviewers were being offered appointment and blood collection contracts being arranged when this became known to the Institute, and no corrective action was taken.

Special selection arrangements applied to Hobart and Darwin, the capital cities where the population is too low to support a CD stage of selection. These arrangements also applied to the growth areas of the Australian Capital Territory where there were insufficiently accurate population counts to enable a CD stage of selection. In these areas, a 0.4% (1 in 250) sample was obtained by dividing the 433 CDs into 2,452 blocks from which 10 were selected.

Probability of selection

As stated above, CDs are chosen for the LFS with an unequal probability of selection. To ensure an equal probability of selection, the CDs on the frame for the NSLC were assigned a probability of selection that would counterbalance the original LFS probability of selection.

Let $P(LFS)_k$ be the probability that a CD of rank 'k' is selected in LFS, where rank identifies the order of rotation of CDs in the LFS. A CD with rank 'k– 1' is the CD behind the CD with rank 'k' where the CDs are in the same State and stratum. Let $P(NFLS)_{k-1}$ be the probability that a CD of rank 'k–1' is not selected in LFS.

Then $P(NLFS)_{k-1} = 1 - P(LFS)_{k-1}$

and the probability that CD_{k-1} is on the NSLC frame is:

$$P(frame)_{k-1} = P(LFS)_k \times P(NLFS)_{k-1}$$

For the NSLC all CDs are required to have the sample probability of selection. However, the probability of a CD being on the sample frame is associated with it being one behind the current CD in the LFS. If N^t is the total number of CDs and n^s is the number of CDs required in the sample, then the probability of selection in the NSLC is n^s/N^t. We then need to solve the following:

$$P(survey)_{k-1} = P(frame)_{k-1} \times f_{k-1} = n^s/N^t$$

where f_{k-1} is the factor to be applied to the probability of a CD being on the frame to ensure that the CDs in the survey have an equal chance of selection. Therefore:

$$f_{k-1} = n^s/N^t \times 1/(P(frame)_{k-1})$$

For example, let $N^t = 10$, and $n^s = 2$, so that the probability of selection in the survey is 0.2. Assume the LFS has currently selected four CDs, so that the frame for NSLC selections also consists of four CDs, each one behind an LFS CD. Call these CDs A, B, C and D and allocate each a probability of being on the frame ($P(frame)_{k-1}$) as in Table A1.

Table A1: Example of the process of selection of CDs for the survey

Selection	$P(\text{frame})_{k-1}$		f_{k-1}	Cumulative f_{k-1}
A	1/10	0.100	2	2
B	1/100	0.010	20	22
C	1/150	0.007	30	52
D	1/200	0.005	40	92

$P(survey)_{k-1} = f_{k-1}/(\sum f)$

$skip = \sum f/n^s = 92/2 = 46$

A start at the beginning of A would result in C and D being selected.

Estimation

Demographic projections of the number of 1- to 4-year-old children of each sex were calculated by the Australian Bureau of Statistics (Table A2). These were used to derive estimates for the Australian population of the number and proportion of 1- to 4-year-old children with a particular property, for example a blood lead level greater than or equal to 0.49 µmol/L.

Let $y_{h,k}$ be an indicator variable for the k^{th} respondent of the h^{th} stratum for the quantity of interest, so that $y_{h,k} = 1$ if the respondent satisfies the criterion of interest, and $y_{h,k} = 0$ if the respondent does not satisfy the criterion. We also need:

h stratum identifier with a different value for each state by sex combination

N total number of 1- to 4-year-olds in Australia

N_h number of 1- to 4-year-olds in stratum (see Table A2)

y_h sum of the $y_{(h,k)}$ for the 1- to 4-year-olds in the stratum, i.e.

$$y_h = \sum_{k=1}^{n_k} y_{h,k}$$

n_h number of 1- to 4-year-olds in the strata that the value of the indicator variable is known for, i.e. set to either 0 or 1

s_h^2 the sample variance of the values $y_{h,k}$, that is the variance of the survey responses for each State by sex strata, given by:

$$s_h^2 = \frac{1}{n_k - 1}\left\{\sum_{k=1}^{n_h}(y_{h,k}^2) - \frac{1}{n_h}\left[\sum_{k=1}^{n_h}(y_{h,k})\right]^2\right\}$$

The estimated number of children is:

$$\hat{y} = \sum_h \frac{N_h}{n_h} y_h$$

with variance:

$$V\hat{a}r(\hat{y}) = \sum_h \frac{N_h^2}{n_h} y_h \left(1 - \frac{n_h}{N_h^2}\right) s_h^2$$

where the summation over h is across the State by sex strata.
The estimated proportion of all children is:

$$\hat{p} = \frac{1}{N^2} \sum_h \frac{N_h}{n_h} y_h$$

with variance:

$$V\hat{a}r(\hat{p}) = \frac{1}{N^2} \sum_h \frac{N_h^2}{n_h} \left(1 - \frac{n_h}{N_h}\right) s_h^2$$

$$= \frac{1}{N^2} V\hat{a}r(\hat{y})$$

Table A2: Estimated number of 1- to 4-year-old children by sex and State or Territory

State	Males	Females
New South Wales	179,678	171,210
Victoria	131,105	124,165
Queensland	97,735	92,109
Western Australia	40,760	38,654
South Australia	51,500	48,964
Tasmania	13,925	13,400
Australian Capital Territory	6,913	6,757
Northern Territory	9,285	8,814
Australia	**530,901**	**504,073**

Source: Australian Bureau of Statistics projections, February 1995.

Appendix 6: Problems with the collection and transport of blood

This Appendix has been included in the report because the National Survey of Lead in Children was the first in Australia to attempt to collect specimens nationwide for analysis in one laboratory. The notes that follow may be of great use in future such surveys.

The Royal North Shore Hospital (RNSH) laboratory noted that 61 specimens from the Sydney region were delivered at ambient temperature. Of those sent by air, 249 specimens were shipped and received at ambient temperature, and a further 221 were shipped with cooling but received at ambient temperature. These numbers represented more than one-third of the airfreighted specimens.

Collection of blood from young children is difficult, and it was to be expected that specimen volume would be limited in some instances. There were nine specimens for which there was insufficient blood for any analysis at RNSH (three of these specimens were sufficient for analysis by ICPMS at Royal Prince Alfred Hospital), and one specimen which could not be analysed due to being fully haemolysed. For a further five specimens for which blood lead level was measured, there was insufficient volume remaining to measure the haematocrit. There were 34 more specimens with volumes estimated at less than 0.5 mL.

Other problems included:

- One specimen was recorded on the Household Form as collected but neither it nor the request form arrived at Royal North Shore Hospital; no explanation was ever obtained. An apology was sent to the parents.
- Staff at one laboratory analysed three specimens and sent the results without specimens to Royal North Shore Hospital. This was rapidly detected by laboratory management and there was no recurrence. The measurements were accepted into the analysis.
- One collector forgot to label tubes containing three specimens collected from two households on the same day. Blood lead levels in these three unlabelled specimens were measured as 0.25, 0.26, and 0.27 µmol/L, so all three were allotted the value of 0.26 for purposes of analysis. Letters of apology were sent to the parents.
- Two collectors sent six and one blood specimens for analysis in tubes other than those supplied. As individual kits were supplied for blood collection, this implies

that all materials used for these seven collections were likely to have been non-standard, and in particular had not been tested for freedom from lead. Nonetheless, the results of analysis were accepted.

- One batch of specimens did not arrive at the Royal North Shore Hospital laboratory until four days after it was sent from Hobart; the package was correctly addressed, and the despatching laboratory had, as requested, alerted the hospital that the batch was in transit. No explanation of how it went astray was ever obtained from the airline. These specimens were all haemolysed on receipt.
- The laboratory received 16 request forms unaccompanied by specimens. In these instances no specimen had actually been collected, but the form had been completed in anticipation.
- In 89 other cases information on the blood tube was either incomplete or different from that on the request form.

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