

The Environmental Case Management of Lead-Exposed Persons Guidelines for Public Health Officers

These guidelines are dedicated to John Feltham, CEng MICE MIMechE MIPENZ RegEng (1931–1997) who made such a significant contribution to improving environmental health in New Zealand.

Citation: Health New Zealand | Te Whatu Ora. 2026. *The Environmental Case Management of Lead-Exposed Persons: Guidelines for Public Health Officers*. Wellington: Health New Zealand | Te Whatu Ora.

These guidelines were previously published by the Ministry of Health, PO Box 5013, Wellington, New Zealand. They have been amended to include WorkSafe New Zealand's updated form for medical officers of health to make notifications under section 199 of the Health and Safety at Work Act 2015.

Published in February 2026 by Health New Zealand – Te Whatu Ora
PO Box 793, Wellington 6140, New Zealand

ISBN 978-1-99-106785-2 (online)

Health New Zealand
Te Whatu Ora

This document is available at [tewhatauora.govt.nz](https://www.tewhatauora.govt.nz)



This work is licensed under the Creative Commons Attribution 4.0 International licence. In essence, you are free to: share ie, copy and redistribute the material in any medium or format; adapt ie, remix, transform and build upon the material. You must give appropriate credit, provide a link to the licence and indicate if changes were made.

Foreword

There is a continued awareness about the hazards associated with lead and the risks, particularly to children, created by exposure to lead from various sources where young children gather and play. Exposure can occur in early childhood education centres and playgrounds, but it is especially likely in the home.

Families in older homes are at risk when lead-based paint is being removed or when it deteriorates (becomes flaky or powdery) and falls off. Soil and dust contaminated with lead in this way become pathways of exposure. There have been cases of children being fatally poisoned as a result of chewing or swallowing lead-based paintwork. Young children are most at risk because of their habit of placing things in their mouths, ingestion of non-food substances (pica), and greater absorption of the lead they take in than older children and adults. Adults may also be at risk from non-occupational exposures due to paint removal, and hobbies particularly, indoor rifle shooting.

Lead absorption is a condition which is notifiable to the medical officer of health under the Health Act 1956 and the Hazardous Substances and New Organisms Act 1996. The levels of blood lead which are required to be notified in New Zealand under the Health Act 1956 are 'lead absorption equal to or in excess of 0.24 $\mu\text{mol/l}$ (5 $\mu\text{g/dl}$)'.

Notification is not an accurate reflection of the problem. Many cases go undetected as the individuals are generally asymptomatic until the blood lead level is at least six times the notifiable level.

These guidelines are intended to be a resource document for public health officers who will be involved in the investigation and management of people who have been exposed to lead.

While the guidelines are applicable for any age, there is an emphasis on measures for managing cases of lead-exposed children. Originally published in 1998 after field testing of interim guidelines for a year and redrafting, these guidelines have been periodically updated to take account of new developments in New Zealand and internationally with respect to management of lead exposure.

Contents

Foreword	3
Contents	4
Introduction	7
Background	7
Purpose of the guidelines	7
Exclusions	8
Chapter 1: Hazard identification	9
Main points	9
Lead in paint	9
Lead in house dust	12
Lead in soil	16
Lead in water	19
Chapter 2: Dose response, exposure assessment, risk characterisation and risk communication	21
Main points	21
Health effects	21
Exposure assessment	25
Risk characterisation	28
Risk communication	28
Chapter 3: Risk reduction	30
Main points	30
Summary of the graded response protocol	30
Risk reduction	33
Graded response protocol	34
Chapter 4: Risk reduction – abatement	44
Main points	44

Introduction	45
Selection of contractors and materials	46
Essential repairs	47
Paint film stabilisation	48
Surface coating	51
Treatment of friction and impact services	54
Paint removal	57
Enclosure	61
Building component replacement	65
Soil cover	67
Water	69
Protection during abatement	71
Clearance testing, ongoing monitoring and re-evaluation	73
Chapter 5: Risk reduction – behaviour modification	76
Main points	76
Introduction	76
House cleaning	77
Hygiene	79
Diet	81
Compliance monitoring and outcome evaluation	83
Chapter 6: Roles and responsibilities	84
Role of public health officers	84
Role of WorkSafe	86
Role of territorial authorities	87
Role of property owners	90
Role of property occupiers	91
References	92
Appendix 1: Lead sampling and analysis	96
Appendix 2: Sample letters for paediatricians and medical practitioners	108

Appendix 3: Report sheets	110
Appendix 4: Work injury notification form	125
Appendix 5: Health advice for indoor target clubs	127
Appendix 6: Minimising lead exposure in target club ranges	131
Glossary	136

Introduction

Background

These guidelines provide practical advice for the investigation and environmental case management of lead-exposed cases. They are intended to assist public health teams achieve a tolerable level of lead in the environment for exposed children or adults, so limiting any adverse effect on their health. Making their environment 'lead safe' will also protect people who might otherwise be exposed to the same lead hazards in the future. Although the guidelines focus on secondary prevention, increasing evidence of the toxicity of lead at levels previously regarded as harmless strengthens the importance of primary prevention (CDC 2012, ATSDR 2020).

Although blood lead levels in the population have reduced considerably in the last few decades, primarily due to the removal of lead from paint and petrol, they remain higher than in the pre-industrial era.

Purpose of the guidelines

The guidelines provide guidance to public health officers on the management of risks to health from exposure to lead in non-occupational settings. Properly applied, the guidelines will assist with determining:

- the risk of a lead hazard
- appropriate advice on managing the risk, including risk communication.

The guidelines will normally be used in the context of 'secondary prevention' when a person is, or is suspected to be, exposed to lead. The guidelines are not intended for primary prevention of hazards arising from lead (eg, inspection, risk assessment and risk reduction from lead in dwellings regardless of a resident's blood lead levels), although many of the basic procedures, sampling and abatement methods would be similar.

While lead-based paint sources will frequently be implicated, the investigation of lead-exposed people should evaluate the contribution of all potential sources to the overall lead exposure. Sources other than lead-based paint include lead transported home on work clothes, hobbies involving lead (eg, lead lighting, graphic materials, indoor rifle shooting¹), lead-based cosmetics and traditional medicines (eg, Ayurvedic remedies), leaded pottery and ceramic glazes, and lead in food and drinking water.

¹ Further information for target ranges is provided in Appendices 5 and 6.

These guidelines assist public health staff to identify all contributory lead hazards and (open) exposure pathways using a combination of interview, visual observation, and laboratory testing. A management plan, typically incorporating both behavioural (educational) and environmental (abatement) strategies, can then be developed in consultation with the household of the affected person. It must be emphasised that the guidelines aim to provide a relatively 'lead-safe' environment, which is not the same as a lead-free environment.

Exclusions

These guidelines exclude places of work because these are covered by the Health and Safety at Work Act 2015 (HSWA). WorkSafe New Zealand (WorkSafe) is responsible for enforcing the Health and Safety at Work Act 2015. The home, public buildings, and schools may be places of work if contractors are doing work in them.

Ambient (outside) air is covered by the Resource Management Act 1991 (RMA). The Ministry for the Environment administers the RMA, and the RMA is implemented by regional councils in so far as it relates to the discharge of contaminants to air. Lead may also occur in ambient air from diffuse sources, but such sources are not considered within the scope of these guidelines. For example, prior to the removal of lead from petrol, vehicle emissions were a significant source of lead in the environment. Ambient air inside dwellings and point source release of lead around dwellings would be covered by these guidelines.

Chapter 1:

Hazard identification

Main points

- Lead-based paint is almost certain to be present on pre-1945 paintwork and is likely to be present on pre-1980 paintwork.
- The US Environmental Protection Agency's hazard standards (USEPA 2019) may be used as a guide:
 - floors (including carpeted floors) $>110 \mu\text{g}/\text{m}^2$
 - interior window sills $>1080 \mu\text{g}/\text{m}^2$
- Lead contamination of soil around residential properties occurs mainly as a result of deterioration, damage or removal of exterior lead-based paintwork.
- The contribution of soil lead to total cumulative lead exposure is highly variable, depending on such things as the content and bioavailability of lead in the soil and the behaviour of people in the household, particularly children.
- The soil contaminant standards (SCS) in the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health are based on people being routinely exposed to bare soil and consuming home-grown produce, where applicable.
- The SCS of $210 \mu\text{g}/\text{g}$ can be considered as a 'level of concern' for a residential setting and is recommended as a trigger for investigation.
- There is evidence to suggest that soil removal and replacement may not be worthwhile as an abatement strategy at soil lead levels less than $3000 \mu\text{g}/\text{g}$, but a more stringent standard, $210 \mu\text{g}/\text{g}$, is likely to be appropriate for sandpit sand or other high-contact areas for young children.

Lead in paint

Introduction

Lead has been used in paint since ancient times, as a pigment and as a drying agent in oil-based paints. The concentration of lead in domestic paints declined dramatically over the latter half of the last century. It may be assumed that pre-1945 interior or exterior

domestic paintwork contains a high lead content; pre-1965 paintwork probably does, while pre-1980 paintwork possibly does. Post-1980 paintwork may generally be assumed to have a very low lead content, unless old stock or industrial specification paint was used (inappropriately).

The list below shows key dates and events in the use of lead in paint in New Zealand.

- Before 1945, white lead (lead carbonate) was extensively used as a pigment in paint, especially exterior house paint (which contained up to 50 percent lead by weight in the dry film) and as a masonry filler mixed with gold size. White lead was progressively replaced by titanium dioxide in domestic paint.
- White lead and lead sulphate were finally banned from paints intended for domestic use in 1965.
- Lead chromate (bright yellows, oranges, and reds generally in top coats) remained in use as an ingredient in domestic paints (for interior and exterior use) until the late 1970s, and possibly until the 1990s by some small suppliers of paint, and is still used for automotive and some heavy duty maintenance paints.
- Red lead was extensively used as a steel primer and was also in wood primers until the late 1970s to early 1980s. Old coats of a primer that appears pink, however, do not always contain red lead, as other pink pigments were and still are used. Some steel-sash putty used to be made up from red lead powder and linseed oil putty; it is unlikely to be found in wooden windows.
- Calcium plumbate was widely used in primers for galvanised steel roofing from its introduction in 1958 until the 1990s. It is no longer manufactured.

Lead-based paint hazards

Lead-based paint will be found on exterior painted surfaces that were constructed or painted prior to 1945, and with reducing probability of it being present as white lead up to 1965. Red lead and lead chromate paints may be found up to the early 1980s (lead chromate possibly later). Calcium plumbate paint (galvanised iron primer) may be found on roofs from 1958 to the mid-1990s. All external surfaces may be affected such as cladding, doors and jambs, windows, painted decking, guttering, downpipes, stairs, railings, outbuildings, fences, and outdoor play equipment.

Interior surfaces constructed or painted before the dates given above may also contain appreciable quantities of lead. Lead-based or lead-containing paint may be present on fixtures and fittings, and building components such as doors and jambs, skirtings, stairs, painted areas of floors, windows and frames. Furniture such as wooden or metal cot railings and children's old toys may also contain lead-based paint. Window putty (particularly in steel windows) may be an additional source.

While a lead-containing paint film is intact, it presents no hazard (other than when direct biting or chewing occurs, which by definition damages the surface), whether or not it is overcoated by a lead-free surface layer. The identification or removal of intact lead-based paint is not the purpose of case management. Instead, investigation of a lead-exposed case should focus on the identification and characterisation of lead-based paint hazards.

A lead-containing paint film becomes hazardous when:

- paintwork is in an advanced state of deterioration (ie, powdering, chalking, blistering, peeling or flaking) and generates small particles that contaminate adjacent soil or become part of interior settled house dust
- paintwork is continually or repeatedly scratched, scraped, rubbed or otherwise worn (ie, friction or impact surfaces such as sash windows, incorrectly hung doors, painted stairs or floors), so it generates lead-bearing dust
- paintwork is being removed (ie, artificially damaged) using an inappropriate method (such as power sanding, abrasive blasting, or open flame burning) that again generates dusts or fumes. This includes lead paint that is covered by a layer of non-lead paint
- paintwork was in the past removed using such unsafe renovation practices, resulting in (extensive) contamination of soil, exterior dust, dust in spaces such as wall cavities, under-floor, roof or ceiling space, and interior settled house dust
- paintwork is in a situation or condition where it may be mouthed, chewed, or eaten (typically this refers to chewable surfaces such as window ledges).

Note that these conditions may create a hazard even when lead-based paint is not the surface layer but is covered by layers of unleaded paint: the full thickness of any multi-layered paint coating must be considered when assessing for hazard.

Identification of lead-based paint hazards therefore requires knowledge of the age of the painted surface (or use of a field test for lead in paint), the past history of (re)painting of the surface, and the condition of the paint on the surface. Paint condition can be assessed in terms of:

- visible bite marks (on a chewable surface)
- evidence of wearing (on a friction or impact surface)
- evidence of powdering, chalking, peeling or flaking (ie, natural deterioration)
- evidence of (past or current) unsafe paint removal (ie, artificial damage).

Standards and extent of potential hazard

Group standards are issued in accordance with the requirements of Part 6A of the Hazardous Substances and New Organisms Act 1996 (HSNO Act). The Group Standards for Surface Coatings and Colourants place restrictions on the lead content and how lead-containing paints can be used in New Zealand. These restrictions prohibit the manufacture, sale, supply or use of paints containing lead carbonate (white lead) except for application as a mirror backing when the paint contains no more than 15 percent of lead in the non-volatile content of the paint.

The Group Standards for Surface Coatings and Colourants also prohibits the manufacture, sale, supply or use of any paint with greater than 0.1% of lead or lead compounds, or greater than 0.2% of lead or lead compounds occurring as an impurity in zinc-based paints for application to:

- a roof or for any surface to be used for the collection or storage of potable water
- furniture
- any fence, wall, post, gate, building (interior or exterior), bridge, pylon, pipeline, storage tank or any similar structure
- any premises used for the manufacture, processing, preparation, packing or serving of products intended for human or animal consumption.

Also, under the Group Standards for Surface Coatings and Colourants it is prohibited to manufacture, sell, supply or use a paint for application to toys unless the paint complies with the specification for coating materials contained in Australian/New Zealand Standard AS/NZS ISO 8124.3:2012 *Safety of toys Part 3: Migration of certain elements*.

Lead in house dust

Introduction

Ingestion of leaded surface dust (settled dust) is the major way young children are exposed to lead. Accessible dust contaminates the child's hands during play and is transferred to the mouth via hand-to-mouth activities such as thumb sucking and nail-biting. Some toys that children may put in their mouths may also be contaminated.

Sources of lead in house dust include lead-based paint, occupational take-home lead, and lead-based hobbies. Lead in petrol was previously also a source. Lead in air results decreased following the introduction of unleaded 91 octane petrol in 1987 (Narsey and Stevenson 1997). Leaded 96 octane petrol was phased out in New Zealand in 1996.

Paint is by far the major source of lead. Leaded dust is generated when lead-based paint:

- deteriorates over time
- is damaged by moisture
- is abraded by friction and impact
- is disturbed in the course of repainting (renovation) or abatement.

Interior lead-based paint contributes directly to house dust lead, while exterior painted surfaces contribute indirectly via soil lead.

Lead in soil derives also from the deposition of lead in air (from stationary sources) and natural sources. Soil particles may be picked up again by wind and carried into the dwelling by wind transport or building ventilation. Alternatively, leaded soil particles may be tracked into the house on shoes or pets. In either case, these particles become components of the house dust.

The rate of deposition and lead content of house dust will therefore be determined by the:

- lead content of paint (correlated with age of the property)
- extent of painted surfaces
- location of painted surfaces (whether exterior or interior)
- condition of paint (whether naturally deteriorated or artificially disturbed)
- extent and type of soil around house and neighbouring properties
- history of external paint removal and hence the degree of soil contamination
- nature of ground cover (particularly location of bare soil areas in relation to painted surfaces)
- distance of property from stationary sources
- magnitude and direction of prevailing winds (and type of building ventilation)
- extent of soil tracking (by people and pets)
- residents' occupations and hobbies.

Bioavailability

The bioavailability of lead in house dust varies with:

- metal species
- particle size distribution

- matrix effects.

Within the living space of the home it is only lead in dust that is directly accessible to the case that creates the hazard. However, dust accumulations in the wall cavities, underfloor space, roof space and ceiling space will contribute to interior dust to the extent that these spaces are not sealed off from the living space. Because the lead content of these dusts may be high (reflecting their origin), their contribution to house dust dynamics needs to be recognised. Rates of deposition and removal of dust in the home will vary between locations and over time, as will the lead content of incoming dust and the thoroughness of cleaning.

Carpets and soft furnishings act as 'dust traps'. Bioavailability of lead in carpet dust may be low. Smaller and heavier particles move deeper within the carpet, making these particles less accessible (carpet beating may be hazardous for this reason).

Vacuuming without a high-efficiency particulate air (HEPA) filter on the exhaust outlet of the cleaner re-suspends very fine, invisible leaded dust particles, which may subsequently settle in more accessible locations. Effective dust control therefore requires use of a vacuum cleaner fitted with a HEPA filter. (Refer to *Vacuuming*, in Chapter 5, for further details.)

Children's behaviour patterns are not static and vary with age. The time spent playing or hiding in different 'micro-environments' (rooms or cupboards) and the activities carried out in these locations will also determine exposure to accessible dust accumulations.

Dust lead loading

Lead exposure via the dust pathway is determined by both the lead content (concentration) of the dust and the amount of dust available (dust loading); that is, the important exposure variable is dust lead loading ($\mu\text{g lead/m}^2$ of dust-bearing surface) rather than dust lead concentration (mg lead/mg dust).

Dust lead loading is a better predictor of children's blood lead levels than is dust lead concentration (Lanphear et al 1994). Furthermore, while abatement interventions would be expected to have some effect on the lead content of house dust (by removing or reducing the intensity of the source, so that lead-rich dust becomes diluted over time with lead-poor dust), their major impact will be on the net amount of dust accumulating, and therefore on dust lead loading.

Monitoring of dust lead loading requires careful attention to the accurate measurement of the surface area sampled, and to timing sample collection consistently in relation to the time at which the collecting surface was last cleaned.

Dust lead standards

Background levels

A 'typical' background value or range for dust lead loading is unrealistic to cite as it is influenced by many variables. These include the:

- lead content of soil and transfer rates of soil particles to dusts in various locations
- lead content of dusts in underfloor and related spaces and transfer rates of dusts between these spaces and the living space
- lead content and deposition rates of interior dusts
- location of the sampling site in relation to lead-based paint hazards
- exterior dust contributions, surface texture, and cleaning routines.

US EPA dust standards

The US EPA has two dust lead hazard standards for floors and interior window sills. Hazard standards for dust were developed by correlating lead in the environment to blood lead concentrations (revised in 2019).

The standards are summarised below, converted to metric measurement and rounded to the nearest 10 µg/m² for ease of use:

1. Hazard standards (USEPA 2019)

- Floors (including carpeted floors) >110 µg/m²
- Interior window sills >1080 µg/m²

The dust lead hazard standard for floors and for interior window sills is based on a weighted average of all wipe samples.

2. Proposed clearance standards (USEPA 2020)

- Floors (including carpeted floors) 110 µg/m²
- Interior window sills 1080 µg/m²

Clearance standards are the maximum amount of lead permitted in surface dust after abatement. These proposed standards have been updated to take account of health risks at lower blood lead levels than recognised when they were originally set in 2001.

These standards should be used as a guide only, particularly if they are applied to soft furnishings.

Lead in soil

Sources of lead in soil

Contamination of soil with lead particles results from deterioration, unsafe removal, or damage to exterior lead-based paintwork; historic use of leaded petrol and (less commonly in New Zealand) stationary sources such as used lead battery collection facilities. Another source may be lead heads off roofing nails, which may find their way into soils after being reduced to fine particles by lawnmower blades.

Lead-based paint hazards typically generate hot-spots of high soil lead concentration within 1 or 2 metres of the painted surface. The past dumping or burning of building debris contaminated by lead-based paint, or the disposal of ash from fires (including indoor fires) may produce hot-spots of high soil lead at a distance from the house. There may be gross contamination of soil, with visible paint flakes and chips, particularly if paint removal has been attempted using unsafe methods.

Exterior dusts, such as street dusts and dust accumulations on paved surfaces (patios, pathways, pavements), may also be contaminated with lead from the same sources.

Deposition of lead particles onto the soil surface is followed by binding to the soil matrix, limiting the metal's mobility to less than 5 cm of soil depth. The extent of binding depends on the soil type (especially organic content) and pH of the soil water.

This does not mean, however, that only the top 5 cm of soil may contain lead. As new soil layers build up on top of older layers, a lead-rich layer (resulting, for example, from a period of house renovation) may sometimes become buried by a lead-poor layer, reversing the usual decreasing gradient of lead in soil with depth. This implies that core samples should be checked if soil removal is being considered as an abatement strategy.

Soil particles rich in lead that are located near the surface may directly contaminate the hands of children and be ingested through normal repetitive hand-to-mouth activity. Soil may also be deliberately eaten by children with pica.

Surface soil particles may also be blown about by wind or may adhere to footwear, toys or pets, and so end up in the interior living space (directly or through an intermediate reservoir such as underfloor or roof space dust), so contributing to interior settled house dust.

The contribution of soil lead to total cumulative lead exposure is highly variable, and is influenced by the:

- lead content of the soil (and profile of lead concentration with depth)

- bioavailability of lead in soil (determined by chemistry and geology of the soil, metal species, and particle size distribution)
- nature, extent and continuity of the ground cover (bare soil is more readily entrained by wind, more likely to adhere to footwear, toys or pets, more likely to contaminate children's hands, and more available to be eaten by a child with pica. A soft cover such as grass or bark chips can reduce exposure by up to 80 percent, and a hard cover such as paving is even more effective)
- physical geography of the site (location of bare soil areas in relation to lead-based paint hazards, principal play areas, pathways, and house entrances)
- meteorological conditions including strength and direction of prevailing winds (in relation to building ventilation)
- transfer rates between soil – exterior dust – underfloor/roof space dust – interior house dust
- behaviour of people and pets.

Standards for lead in soil

Background levels

There is a wide range in reported 'background' levels for lead in New Zealand soils, ranging from 20 µg/g (ppm) in pristine rural soils to over 200 µg/g in older urban neighbourhoods.

Soil lead and blood lead

Weitzman et al (1993) carried out studies in Boston of the effects on blood lead of various abatement interventions with the objective of determining the independent effect on blood lead from reductions of lead in soil accessible to children. Soil contaminated to a median surface lead level of 2075 µg/g was removed and replaced. The average drop in soil lead levels was 1790 µg/g and was accompanied by a decline (after 11 months) independently associated with soil abatement, ranging from 0.8 to 1.6 µg/dl when confounders such as water, dust and paint lead levels, children's behaviours and other characteristics were controlled for. The curve gives a similar reduction in blood lead over the same range of soil lead. This implies that soil removal and replacement may not be worthwhile as an abatement strategy at soil lead levels less than 3000 µg/g.

Lanphear et al (2003) found, after adjustment for confounders, residential soil removal and replacement at levels above 500 µg/g led to a 2.5 µg/dl decline in blood lead among children aged six months to three years. There was an estimated 3.5 (95% CI 2.4–4.6) µg/dl reduction in blood lead level among this age group for every 1000 µg/g reduction in soil lead. No significant reduction in blood lead level was found for children aged three to six years.

Studies by Weitzman et al (1993) and Lanphear et al (2003) for soil lead levels in the range of 1000 to 3000 µg/g, suggest soil removal is probably not indicated, and measures such as improving ground cover and behaviour modification (eg, relocating the principal play area away from the house) may suffice. At soil lead levels less than 1000 µg/g bare soil areas should still be covered (a soft cover such as grass or bark chips is generally adequate), if indicated by use pattern analysis, as soil lead tracked or blown into the house will be contributing to dust lead in the home.

Soil Contaminant Standards (SCSs)

The Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES) provides the SCS for lead in soil. The SCSs have regulatory status under the NES and act as trigger for resource consent requirements. Existing uses are not affected by the regulation. The NES only applies at the time of subdivision, land use change, major soil disturbance, soil sampling or removal of fuel storage systems.

These values are risk based and were derived from the most up to date toxicological and epidemiological information. The focus of the NES is to ensure that human health is protected from the adverse effects of certain hazardous substances in the soil. The SCS is conservative compared with other jurisdictions' soil guideline values as it was based on the Joint Food and Agriculture Organization of the United Nations/World Health Organization's Expert Committee on Food Additives' (JECFA) conclusion to withdraw the potential tolerable weekly intake (PTWI) of 25 µg/kg body weight as it could no longer be considered health protective (FAO/WHO 2011).

The PTWI of 25 µg/kg body weight for lead is associated with a decrease of at least three IQ points in children and an increase in systolic blood pressure of approximately 3 mmHg (0.4 kPa) in adults. While such effects may be insignificant at the individual level, these changes are important when viewed as a shift in the distribution of IQ or blood pressure within a population. As the dose response analyses do not provide any indication of a threshold for the key adverse health effects of lead, JECFA concluded that it was not possible to establish a new PTWI that would be health protective.

In cases of a non-pica child who may play outside on a high contact area, soil abatement by improving ground cover (eg, grass, bark chips) and behaviour modification (eg, relocating the principal play area away from the house) may suffice in most cases. A stricter standard of 210 µg/g is likely to be appropriate for a small high-contact area such as a sand pit (given its uncovered nature and pattern of activities associated with it).

Stricter standards would also be appropriate for families with a pica child. Careful questioning of caregivers and time spent directly observing child behaviour is valuable when it comes to assessing the health risk from elevated soil lead levels.

The summary of SCSs for inorganic lead is shown below.

Lead levels – soil contaminant standards	µg/g
Rural residential/lifestyle block 25% produce	160
Residential 10% produce	210
High-density residential	500
Recreational	880
Commercial/industrial (outdoor worker or unpaved)	3,300

Lead in water

Sources of lead in water

There is potential for elevated lead levels in drinking-water from dissolution of lead pipes and solders, and brass fittings in homes. Leaching of lead from newly fitted uPVC pipes has been overcome by the introduction of a New Zealand standard.

The amount of lead dissolved is dependent on, amongst other things, pH, temperature, stagnation time and water hardness.

An assessment of the levels and sources of lead in school drinking-water in New Zealand showed that neither industrial nor vehicular air pollution by lead-containing compounds were considered to be significant contributors to lead levels in drinking-water (Ministry of Health 1996). The lead appeared to have entered the supply through dissolution from the reticulation and/or in the case of roof catchment from components of the rainwater collection system, such as lead-head nails, lead flashings and lead soldered storage tanks.

The lead levels in many of the first flush water samples taken from systems terminations had significantly higher lead levels than those of the second flush samples. This suggested that lead levels originate not from the rain water collection system, but rather from the reticulation.

Levels at drinking fountains were generally higher than those taken elsewhere in the reticulation. The long runs of reticulation to the drinking fountain was considered a contributory factor in the higher lead levels. The softness of rainwater and plumbosolvency of the catchment and distribution systems are critical contributing factors to elevated lead levels.

Standards for lead in water

Drinking-water is regulated by Taumata Arowai, and covered by the Water Services Act 2012 and the Water Services (Drinking Water Standards for New Zealand) Regulations 2022. The Water Services (Drinking Water Standards for New Zealand) Regulations 2022 provide a maximum acceptable value (MAV) of 0.01 mg/l for lead.² While first draw water (ie, taking directly from the tap without flushing) may sometimes contain lead in excess of this concentration, in almost all cases flushing a mugful of water from drinking water taps each morning will reduce its concentration to less than 50 percent of the MAV because the primary sources in most dwellings is the brass of the tap or associated fittings.

² <https://www.legislation.govt.nz/regulation/public/2022/0168/latest/whole.html>

Chapter 2:

Dose response, exposure assessment, risk characterisation and risk communication

Main points

- Determine exposure pathways.
- Identify the lead-based paint hazard, such as visible bite marks, evidence of wearing, evidence of powdering, chalking, peeling or flaking, or evidence of unsafe paint removal.
- Dust is the major pathway of exposure to lead for children, and lead-based paint is the major source of this lead.
- Dust lead loading (expressed as $\mu\text{g}/\text{m}^2$ of dust-bearing surface) is the most important exposure variable.
- The amount of lead ingested and absorbed by children depends on dust lead loading, child behaviour, and bioavailability of lead in house dust.
- About 25 percent of two-year-old children display some degree of pica behaviour. A two-year-old can ingest approximately 100 mg of soil per day through hand-to-mouth activity.

Health effects

Lead is a persistent environmental pollutant, and it is widely distributed throughout the built and natural environment. It causes a variety of symptoms, some of which are indistinguishable from other causes, and may ultimately result in death. The most well-studied health outcomes are neurological, renal, cardiovascular, haematological, immunological, reproductive, and developmental effects. Neurological effects of lead are of greatest concern (ATSDR 2020). Lead affects the developing brain and nervous system and can result in impaired cognitive and neurobehavioural development of children.

The uptake of lead in the non-occupational environment is predominantly from dust or fume inhalation, and the ingestion of paint fragments or dust (directly or via contaminated food stuffs). The primary route of uptake among children is ingestion, particularly among preschool children, who tend to eat, chew, lick or suck non-food items (including contaminated fingers). Seasonal variations in blood lead levels in children have been

found, with a general trend of increasing concentrations during late summer and early autumn (ATSDR 2020).

Adults tend to inhale lead, typically as dust arising from domestic cleaning and renovation activities, or fumes from firing a firearm. Poor personal hygiene before smoking or eating may also result in appreciable ingestion where hands are contaminated from activities eg, paint removal or indoor rifle shooting.

Once in the body, lead may pass into the bloodstream or be excreted via faeces and urine. The rate of uptake depends upon many factors, not least the chemical and physical form of lead and nutritional status. Once in the bloodstream, lead tends to accumulate rapidly in hard tissues such as bones and teeth, from which it may be slowly released back into the bloodstream. Up to 90 percent of body lead burden may be found in bones.

The rate of release is largely governed by blood lead concentration relative to that of the accumulation sites. When the uptake rate exceeds the excretion rate, there is a net accumulation of lead in the body and symptoms of lead toxicity will ultimately occur.

Health effects are the same irrespective of the route of exposure. The early stages of lead toxicity are non-specific and affect the haematopoietic, gastrointestinal and nervous systems. Genetic predisposition can also affect vulnerability to lead-induced neurotoxicity. In later stages, symptoms may develop in the blood, kidneys, bones, heart and reproductive systems and may, in extreme cases, cause death. One of the most important manifestations of lead exposure is developmental impairment in children.

Symptoms of lead toxicity involving the nervous system can include:

- mood changes such as depression or irritability
- memory impairment
- sleep disturbance
- concentration difficulties
- headaches
- tingling and numbness in fingers and hands
- muscle weakness and wrist drop (heaviness of limbs)
- fits (rarely).

Symptoms of lead toxicity involving the gastrointestinal system can include:

- lack of appetite
- nausea

- diarrhoea
- constipation
- stomach pains
- weight loss.

Other effects may include:

- kidney damage and increased blood pressure
- decrease in numbers and quality of sperm
- miscarriage
- anaemia.

Although clinical symptoms of lead toxicity generally become apparent at blood lead concentrations above 3.38 $\mu\text{mol/l}$, cognitive deficits have been observed in children at blood lead levels previously thought to be harmless, with effects now recognised below 0.24 $\mu\text{mol/l}$ (ATSDR 2020). In addition, most children suffering from elevated blood lead levels are asymptomatic or have non-specific symptoms.

Whilst a number of effects have been seen at blood lead levels below 0.24 $\mu\text{mol/l}$, the evidence is strongest for cognitive deficits in children (ATSDR 2020). Systematic reviews have concluded that blood lead levels below 0.48 $\mu\text{mol/l}$ are associated with several adverse health effects (National Toxicology Program 2012; US EPA 2013; National Health and Medical Research Council 2015). Among the health effects that are associated with levels below 0.48 $\mu\text{mol/l}$ are:

- decreased IQ and academic achievement in children
- adverse behavioural effects (attention, impulsivity and hyperactivity) in children
- delayed sexual maturity or puberty onset in adolescents
- increased blood pressure and risk of hypertension among adults and pregnant women.

The National Toxicology Program systematic review (2012) of epidemiological literature concluded that there was sufficient evidence of an association between health effects and low-level lead exposure. The US Environmental Protection Agency systematic review (2013) of published studies concluded that the relationship was causal. Armstrong et al (2014) who reviewed these systematic reviews, along with human epidemiological studies on the health effects of blood lead levels less than 0.48 $\mu\text{mol/l}$ (published from 2004 – mid-May 2013) disagreed with the conclusions of the two systematic reviews. Armstrong et al instead claim that the evidence was suggestive rather than definitive of an association as the human evidence was from observational studies.

Several studies have suggested that the exposure-response to lead is non-linear, and that for a given increase in blood lead, the associated decrease in IQ and academic achievement is greater at blood lead levels below 0.48 $\mu\text{mol/l}$ than at higher levels (Canfield et al 2003; Bellinger and Needleman 2003; Lanphear et al 2005; Crump et al 2013; Evens et al 2015). In contrast, the evidence for an association between prenatal lead exposure and child IQ is inconsistent (Taylor et al 2017). A longitudinal study found a stronger relationship between blood lead concentration and IQ at ages five and seven years despite lower blood lead concentrations at these ages than when they were two years. This suggests that a child's blood lead level until school age and not the peak level which typically occurs at two years is important for optimum cognitive development (Chen et al 2005).

Effects of childhood lead exposure on cognitive development appear to be irreversible (Tong et al 1998; Reuben et al 2017). Follow up of the Dunedin Multidisciplinary Health and Development Study cohort at age 38 found childhood lead exposure was significantly associated with lower adult IQ and socioeconomic status, after adjusting for childhood IQ, maternal IQ and childhood socioeconomic status (Reuben et al 2017).

Although effects of low lead levels are not likely to be recognisable or measurable in an individual child, they are important on a population basis. Relatively small changes in the average IQ of many children increases the proportion below any IQ level of concern at which additional educational assistance may be required and decreases the proportion above any 'gifted' level.

The general state of health may influence the severity of symptoms, as lead already in the body may be mobilised during pregnancy, menopause or ill-health, or due to excessive alcohol consumption. Lead can cross the placental barrier and affect an unborn child.

The intensity of exposure may vary greatly, and the effects of exposure may thus be acute (resulting from short-term, intense exposure) or chronic (resulting from prolonged low-intensity exposure).

As lead is a bioaccumulative toxin, prolonged exposure to a low level of contamination can lead to appreciable concentration in the body over time.

A meta-analysis of 31 studies found a weak association between blood pressure and blood lead level. A twofold increase in blood lead level was associated with a 1.0 mm Hg rise in systolic pressure and 0.6 mm Hg increase in diastolic pressure (Nawrot and Staessen 2006).

The International Agency for Research on Cancer (IARC) has classified inorganic lead compounds as probably carcinogenic to humans (Group 2A) while organic lead compounds are not classifiable as to their carcinogenicity to humans (Group 3) (IARC 2007).

Exposure assessment

Knowledge of exposure is essential for environmental epidemiology and hazard control. The measurement of exposure to lead can be determined by absorbed dose. The sources of exposure can be determined by exposure characterisation using questionnaires, interviews, inspections, historical records, and/or exposure simulations.

Lead paint exposure pathways

Lead-based paint is generally the major source of both lead in soil and lead in house dust. These are typically the more important pathways of exposure, particularly the latter, due to the greater bioavailability of small particle lead. However, the relative contributions of direct consumption of paint, soil ingestion, and ingestion of house dust, to blood lead will vary with the situation, depending on both environmental and behavioural factors.

Paint may be directly consumed by children, particularly if it is flaking or peeling. Lead paint has a sweet taste and is attractive to children, whether or not they have a general tendency to consume non-food items such as soil (ie, pica). Children may also chew or bite into (previously) intact painted surfaces, so damaging these surfaces and ingesting paint. Window sills (ledges), doors, cot railings, and toys are typically preferred for chewing or biting.

Adults involved in paint removal inhale lead directly from paint dust or ingest it if they have not washed their hands before smoking or eating.

Cumulative exposure via house dust

Adults who may be exposed to hazardous amounts of dust include:

- those involved in paint removal operations
- those living where dust residues contain high lead levels arising from historical or ongoing paint removal operations
- those whose hobbies expose them to other sources of lead, particularly firearms users.

Dust lead loading, behaviour, and bioavailability of lead in house dust interact to determine cumulative absorption of lead from house dust. The factors influencing these variables, and potentially controllable by environmental and behavioural intervention strategies, may be summarised as follows:

1. time spent by the person in different microenvironments (rooms, cupboards)

2. activities of the person in each microenvironment (extent of hand contamination and hand-to-mouth transfer)
3. household activity, for example, cleaning methods which extract dust from carpets or other surfaces and may increase the deposition rate
4. lead concentration of the dust in each microenvironment
5. dust loading in each microenvironment (ie, net dust accumulation, determined by the difference between deposition rate and removal rate)
 - deposition rate is determined by the location of sources and ventilation pattern
 - removal rate is determined by the surface texture and cleaning routine
 - the product of 3 and 4 is the dust lead loading
6. bioavailable fraction (influenced by chemical species, particle size distribution, matrix effects, and physiological and genetic factors influencing gut absorption).

Pathways of exposure to lead in soil

Soil ingestion

Children are most at risk of soil ingestion, mainly from outdoor play. Several studies have shown a correlation between hours spent playing outdoors and blood lead level, especially for preschool children.

Exposure results from normal play activity, leading to hands getting 'dirty' followed by hand-to-mouth activity (thumb sucking, nail biting) or eating without washing hands. Food may also be eaten after falling onto the ground. Toys and similar objects may be mouthed after coming into contact with soil, or act as vehicles for transfer of leaded particles from soil to hands.

It has been estimated that a two-year-old ingests approximately 100 mg of soil per day through such activities, with younger and older children ingesting less.

The key factors influencing exposure from playing outdoors are:

- soil lead concentration and bioavailability
- ground cover
- use patterns (time spent in different outdoor microenvironments, play activities, pica behaviour).

Pica

It is believed that up to a quarter of two-year-old children display some degree of pica behaviour (eating of non-food items including soil), although in only a minority is this behaviour marked. Pica is less common in children both younger and older than two years. In some cases, pica is associated with iron deficiency or cognitive or behavioural problems, but often there is no obvious cause.

A pica child may ingest significant amounts of lead from soil that is near or even below guideline levels. The child may also target 'hot spots' where there is a localised elevated level of lead in the soil.

Any degree of pica places the child at increased risk of lead exposure (from soil) and should be taken seriously. Careful questioning and direct observation may be required to identify and evaluate pica behaviour.

Home-grown vegetables

Because of its limited mobility in soil, little lead is absorbed through the roots of plants. However, soil on harvested root crops may be ingested, if not fully washed off before eating.

In addition, fallout of lead in air may directly contaminate leaves and other above-ground parts of plants; broad leafy vegetables are most likely to be affected.

Home-grown vegetables may therefore make a contribution to dietary lead intake, albeit usually a minor one. Vegetable gardens planted close to major lead-based paint hazards should receive attention. Gardens remote from current lead hazards may also be contaminated from prior use of the site or windblown dusts and may also need assessment on occasion.

Dust ingestion

Soil particles are one of the components of house dust. Except for the pica child, house dust is likely to be the major route of most people's exposure to soil lead.

The relative contribution of soil and other routes to the 'final common pathway' of interior settled house dust exposure varies, depending on:

- lead content of the soil
- transfer rate of particles between soil and house dust (directly and via such intermediate reservoirs as underfloor and roof space dusts)
- contribution from interior sources.

Risk characterisation

Risk characterisation combines the information obtained from the hazard identification, dose-response assessment, and exposure assessment to estimate the risk associated with each exposure scenario considered, and to present uncertainties in the analysis.

Notification of 'lead poisoning' under the Health Act 1956 was amended in 2021 to a blood lead of 0.24 $\mu\text{mol/l}$ or greater for all ages. It should be noted that values for venous blood, not capillary blood (finger pricks), should be used for determining action.

Clinical management of the case can be related directly to cumulative exposure, as this determines the severity of health effects and the treatment necessary (eg, chelation therapy for heavily exposed cases). Blood lead level is more closely related to short-term (past three to four weeks) than cumulative exposure but nevertheless provides a useful biomarker for the latter.

The environmental management strategy can also be based on the person's blood lead level, acting as a crude indicator of the extent of environmental lead contamination. It is desirable that lead hazards be removed wherever possible, because behavioural strategies benefit only those people who are currently at risk, and are a less certain way of controlling exposure than environmental modification. However, lead is widespread in the general environment. This means there is a 'law of diminishing returns', with little benefit to be expected from abatement at levels of environmental contamination corresponding to blood lead levels of approximately less than 1.21 $\mu\text{mol/l}$. Below this level, behavioural adjustment alone will usually suffice and extensive environmental sampling is not generally necessary, although any obvious lead hazards should still be abated.

At higher blood lead levels, or if the blood lead level fails to fall as expected or rebounds, more extensive environmental management is necessary (together with behavioural strategies).

The scope and scale of clinical and environmental response can therefore be graded according to the blood lead level of the case at notification (confirmed by an independent rebleed if close to a trigger value), although this should be interpreted flexibly according to the specific circumstances of each case.

Risk communication

Community perception of risk is not based on technical risk assessment alone. Public recognition of risks, in contrast to risk assessment based on probabilities prepared by experts, includes intuitive risk perception. The characteristics of such perception are related to concepts of fairness, familiarity, future and present 'catastrophic potential', and outrage at involuntary exposure to hazards not of their making.

Risk communication needs to be a two-way process and ongoing, as described in some detail the USEPA's *Risk Communication in Action: The risk communication workbook* (Reckelhoff-Dangel and Petersen 2007). The goal of risk communication is to establish trust and credibility. It needs to be done in such a way that people are well informed and guided in the actions they can take, while knowing that the experts are also taking account of, and acting on, people's concerns.

Specific situations may arise that require a proactive response from the public health officer. For example, an early childhood centre or school may have become identified as being lead contaminated as a result of poor maintenance, repainting or renovations (Gray et al 2009). It is important to recognise that parents and caregivers are likely to become very concerned if they are aware of raised environmental lead levels in the preschool or primary school environment. Information needs to be provided directly to parents and caregivers, through information sheets and/or public meetings, and via the media. This information should acknowledge the concerns but place them in the context of the children's overall exposure. It should be clearly explained that the risk is generally low (in the absence of other exposures such as from elevated lead in the home environment) and that children are unlikely to need blood testing.

Chapter 3:

Risk reduction

Main points

- The focus of any investigation into lead-based paint should be on the hazards present (not just the identification of lead-based paint).
- A management plan to reduce lead exposure in the home should incorporate both behavioural (educational) and environmental (abatement) strategies.
- Risk reduction strategies should be appropriate to the scale and significance of the exposure to lead.
- Lead absorption equal to or in excess of 0.24 $\mu\text{mol/l}$ is notifiable to the medical officer of health under Section B of Schedule 2 of the Health Act 1956.
- All lead absorption notifications should be entered into the Hazardous Substances Disease and Injury Reporting Tool.

Summary of the graded response protocol

The following recommendations provide an indication of appropriate responses to the results of the most recent blood test from the affected child (or non-occupationally exposed adult). These recommendations are based on international and national standards, but for all individual cases public health officers should also be guided by the medical practitioner.

Blood lead $\geq 2.17 \mu\text{mol/l}$

- Arrange urgent paediatric assessment. Advice for medical practitioners about chelation therapy is available from TOXINZ or the National Poisons Centre.
- Refer adults to a physician if blood lead is $\geq 3.4 \mu\text{mol/l}$.
- Investigate sources of, and pathways of exposure to, lead using the standard questionnaire, visual observations, spot tests for lead-based paint, and laboratory analysis of appropriate environmental samples (paint, dust, soil, other).
- Abate all identified lead hazards (if the source is the house, temporary relocation will generally be recommended particularly if the case is a young child or more than one member of the house has a high blood lead level).
- Advise on behavioural strategies to reduce exposure to and absorption of lead.

- Check on environmental lead levels after abatement work has been completed.
- Modify intervention strategy and permit re-occupation depending on results.
- Monitor compliance with behavioural routines at three- to six-monthly intervals.
- Carry out further rounds of post-abatement environmental sampling as necessary.
- Monitor blood lead at six weeks then after another six months, and then annually to age six or until results fall below 0.24 $\mu\text{mol/l}$.

Blood lead 0.96 – 2.16 $\mu\text{mol/l}$

- In consultation with the child's general practitioner, refer to a paediatrician for assessment and possible neurodevelopmental testing (if not already done).
- Investigate sources of, and pathways of exposure to, lead using the standard questionnaire, visual observations, spot tests for lead-based paint, and laboratory analysis of appropriate environmental samples (paint, dust, soil, other).
- Abate all identified lead hazards
- Advise on behavioural strategies to reduce exposure to and absorption of lead.
- Check on environmental lead levels after abatement work has been completed.
- Modify intervention strategy and permit re-occupation depending on results.
- Monitor compliance with behavioural routines at three- to six-monthly intervals.
- Carry out further rounds of post-abatement environmental sampling as necessary.
- Monitor blood lead at six weeks then after another six months, and then annually to age six or until results fall below 0.24 $\mu\text{mol/l}$.

Blood lead 0.72 – 0.95 $\mu\text{mol/l}$

- Notify the child's general practitioner and discuss need for testing for iron deficiency anaemia and depending on the child's age, possible referral for neurodevelopmental testing.
- Investigate sources of, and pathways of exposure to, lead using the standard questionnaire, supplemented by visual observation and lead-based paint spot testing as needed. Abate any obvious lead hazards.
- Advise on behavioural strategies to reduce exposure to and absorption of lead.
- Monitor blood lead at six weeks then after another six months, and then annually to age six or until results fall below 0.24 $\mu\text{mol/l}$.

Blood lead 0.48 – 0.71 µmol/l

- Investigate sources of, and pathways of exposure to, lead using the standard questionnaire.
- Advise on strategies to reduce exposure to and absorption of lead.
- Repeat blood lead test at least six weeks following completion of abatement.
- If still within this range after retesting:
 - supplement earlier history taking with visual observation and lead-based paint spot testing as needed
 - abate any obvious lead hazards advise on behavioural strategies to reduce exposure to and absorption of lead
 - monitor blood lead after another six months, and then annually to age six or until results fall below 0.24 µmol/l.

Blood lead 0.24 – 0.47 µmol/l

- Investigate sources of, and pathways of exposure to lead, using the standard questionnaire, particularly if the person is a child or a pregnant woman.
- Advise on strategies to reduce exposure to and absorption of lead.
- Repeat blood lead test at three months following completion of abatement (the 6-week time for a repeat test noted for the level in the graded response protocol noted above may be too short a time to reliably detect a reduction in blood lead level at these lower levels).
- If still within this range after retesting:
 - supplement earlier history taking with visual observation and lead-based paint spot testing as needed
 - abate any obvious lead hazards advise on behavioural strategies to reduce exposure to and absorption of lead
 - monitor blood lead after another six months, and then annually to age six or until results fall below 0.24 µmol/l.

Note: if health protection staff are unable to follow up all notifications because of resource limitations, all notifications of children (ie, under 15 years) or pregnant women must be investigated. Given that the latter cannot be determined from direct laboratory notifications, all women of childbearing age (<45 years) should be investigated in these instances. Other notifications (ie, all women ≥45 and men ≥15 years) in this blood lead range should

be sent information about lead absorption and reducing lead exposure and absorption of lead but an active investigation may not be required if resources are constrained.

Blood lead level <0.24 µmol/l

- No action required (unless there is another reason to investigate for a possible environmental lead hazard).

Lead absorption equal to or in excess of 0.24 µmol/l is notifiable to the medical officer of health under Section B of Schedule 2 of the Health Act 1956. All lead absorption notifications should be entered into the Hazardous Substances Disease and Injury Reporting Tool. Data are analysed annually by the Environmental Health Indicators programme, Massey University (www.ehinz.ac.nz) and reported to the Minister of Health by Te Whatu Ora.

Lead poisoning from occupational exposures is notifiable (by medical officers of health) to WorkSafe under section 199 of the Health and Safety at Work Act 2015. More information about notification and the role of WorkSafe is provided on page 85. Appendix 4 contains the notification form that has been provided to local public health services.

WorkSafe will consider whether a worker should be suspended from work, and the suspended worker may only return to work when follow-up tests indicate that the blood lead level has reduced to an acceptable level (**Lead, inorganic dusts and fumes, as Pb | WorkSafe**).³

Risk reduction

The range of risk reduction alternatives must be evaluated, including the social, economic and cultural implications of options.

This could be achieved along two lines: the control of actions and events that can translate a lead hazard into a lead risk, and the removal or near-permanent containment of the lead hazard.

Lead exposures in non-occupational settings may vary greatly. A protocol for the management of such exposures should aim to provide a response that is graded according to the likely harm.

³ <https://www.worksafe.govt.nz/topic-and-industry/monitoring/workplace-exposure-standards-and-biological-exposure-indices/all-substances/view/lead-inorganic-dusts-and-fumes-as-pb>

Graded response protocol

The investigation and follow-up will be delivered over a series of visits and other contacts with the family (and other stakeholders). The exact number of visits, and precisely what is accomplished on each occasion, will vary depending on the graduated nature of the response and the unique circumstances of each case. The steps outlined below provide general guidance for the 'typical' case.

Stage 1: Initial investigation

1. Using the report sheets (Appendix 3), collect information from the principal caregiver (and other residents if appropriate) on:
 - current and past health status of the index case (including blood lead levels)
 - other children (including frequent visitors) who may also have been exposed
 - past, present and future environments that may have placed/may place the case at risk of lead exposure (including dwellings, early childhood centres)
 - lead-based paint hazards and other lead hazards to which the case may have been/may be exposed (including household members' occupations, traditional medicines and hobbies which may involve lead)
 - possible (open) pathways of exposure to these hazards
 - behavioural risk factors for exposure to or absorption of environmental lead.
2. Supplement information obtained by interview with visual observation of:
 - implicated environments, for evidence of lead-based paint and other lead hazards (use lead-based paint spot test as required, see Appendix 1: Testing for lead-based paint)
 - case behaviour, for evidence of risk factors for exposure to or absorption of lead (including location of principal play areas, extent of repetitive hand to mouth and mouthing behaviour, chewing on painted surfaces, pica)
 - household cleaning, hygiene and dietary routines.
3. Record data in the Record Sheets (Appendix 3). Locate lead-based paint hazards and principal play areas on the sketch map.
4. Based on this information, in consultation with the medical officer of health, decide whether or not to re-test the index case (to check blood lead). This will be influenced by the:
 - number of previous blood lead tests

- currency of most recent blood lead test
 - closeness of reported blood lead to one of the trigger values outlined at the beginning of this chapter
 - inconsistency between reported blood lead and apparent extent and duration of lead exposure.
5. Similarly, decide whether or not to test other household residents, frequent visitors to the household (or early childhood service), or pets (to assess blood lead as a biomarker of lead exposure). This will be influenced by:
 - vulnerability (preschool children, pregnant women)
 - likely sources and pathways of exposure.
 6. Also decide (based on the information collected) which environments to investigate for lead hazards and exposure pathways. These may include:
 - environments in which the case currently spends significant time (more than five hours/week approximately) (including houses of grandparents or other relatives and extended family/whānau members, neighbours, friends, and early childhood centres, as well as the case's current usual residence)
 - settings in which the case has in the past spent significant time (in particular, previous residences and early childhood services where the case has lived or attended for more than six months).
 7. If the decision is made to investigate any premises other than the current ones, then the appropriate sections of the questionnaire and visual observations (and spot tests) will need to be completed for those premises as well.
 8. The questionnaire and visual observational data may be sufficient to clearly identify the likely source(s) and pathway(s) of lead exposure involved. If, in addition, the blood lead of the index case (pre-chelation) is less than 1.2 $\mu\text{mol/l}$, environmental sampling is unlikely to influence further management. Under these circumstances, Step 2 (*Environmental Sampling*) may be omitted.

Stage 2: Environmental sampling

1. Prepare a sampling plan based on information about likely sources and pathways from interview and visual observation. This will typically include samples of paint (if lead-based paint hazard(s) suspected) but occasionally of other sources such as ceramics, graphic materials, traditional medicines, drinking-water, and the major lead reservoirs such as dust and soil.

A very important indicator of lead contamination can often be the obvious physical presence of lead flakes or dust. In a situation where the paint is known to contain lead, either through historical information (for example, the age of the building) or a presence or absence test, the presence of lead flakes or dust can often be used as an important tool, whilst waiting for confirmatory analysis results to become available.

2. Lead-based paint hazards include:

- chewable painted surfaces (visible bite marks)
- friction and impact surfaces (evidence of paint wearing and paint chips)
- deteriorated paint (powdering, peeling, flaking, blistering or all of above)
- unsafe paint removal (past or current renovation/repainting).

Sampling of paint (refer Appendix 1) will be guided by age of the building component, condition of the painted surface, and history of renovation. In most circumstances, a field test (lead-based paint spot test, see *Testing for Lead-Based Paint*, Appendix 1) will suffice. Laboratory paint chip analysis should be used when the field test returns an unexpected result (ie, positive or negative or unclear, contrary to other evidence).

It is not the identification of lead-based paint but of lead-based paint hazards that is relevant – intact lead-based paint is not a health risk (except on toys, children’s furniture and other chewable surfaces).

3. Sampling of dust will be guided by knowledge of likely sources of lead loading, use patterns (location of principal play areas), and cleaning routines.

Sampling locations need to be carefully selected, and samples must be collected using a standardised technique and timed in relation to the time of last cleaning of the surface involved.

In all but the most specialised situations, the wipe method is the preferred sampling technique for the measurement of indoor lead loading. Lead-containing material can become embedded within the pile of a carpet, for example, but it is only particles in the superficial layers which are likely to be able to be ingested or inhaled. Should other sampling methods be considered (for example, the vacuum method) laboratory advice must be sought prior to sampling.

Provided these precautions are adhered to, the results can be helpful not only for risk assessment (by comparison with a recognised standard), but also for evaluation of intervention (‘clearance’) (by comparison of ‘before’ and ‘after’ samples).

4. Sampling of soil (refer Appendix 1) will also be guided by knowledge of likely sources, use patterns (location of principal play areas), presence of behavioural risk factors (especially pica), and nature of the ground cover.

Visible paint flakes can be taken as evidence of high-level soil contamination (if the paint is lead-based), avoiding the need for laboratory testing in this situation.

Also, soil abatement typically makes only a minor contribution to lead exposure control. An exception to this is the child with pica. In this situation, soil testing is of greater value.

5. Indicate the location and coding of environmental samples on a sketch map. The sketch map can illustrate sampling sites in relation to lead-based paint hazards and principal play areas.

Enter field and laboratory test results onto the tables provided in the report sheets (Appendix 3), for ease of before/after comparisons or comparison with standards.

Stage 3: Risk reduction planning

1. Revise the initial assessment of sources/pathways/behavioural risk factors based on the result of laboratory analysis of the environmental samples, and further blood tests and clinical examinations.
2. Based on this understanding of the hazards and behaviours leading to lead exposure/absorption, design a risk reduction strategy in partnership with everyone who occupies the premises. Other stakeholders such as property owners and insurers may also need to be involved or kept informed. Insurers may accept the cost of some abatement work. The options for risk reduction include environmental (abatement) and behavioural (educational) strategies as outlined in the Summary of the graded response protocol, at the beginning of this chapter.
3. Environmental strategies include complete elimination (or near permanent enclosure) of the source, and interventions aimed to reduce the intensity of the source or exposure to it. Only the former are regarded as abatement strategies in the United States; the term 'interim control measures' being applied to the latter. However, 'abatement' is used inclusively in this guideline, in accordance with conventional New Zealand usage of the term.

The major abatement strategies for lead-based paint hazards are:

- paint film stabilisation
- treatment of friction and impact surfaces

- surface coating
- enclosure
- building component replacement
- controlled paint removal.

Enclosure, and (under suitable conditions and if available) surface coating, can provide abatement with a life of at least 20 years. Building component replacement and paint removal eliminate lead-based paint hazards permanently.

Paint film stabilisation, and treatment of friction and impact surfaces will generally have an effective life of less than 10 years but, properly maintained and renewed, they can be effective indefinitely. Careful periodic monitoring is required that is more demanding than the monitoring of enclosures.

Associated with every method of abatement is the need for meticulous care to avoid further lead contamination of the home environment and very thorough cleaning as a part of the abatement process.

Soil abatement strategies include:

- soft cover (grass, bark chips)
- hard cover (paving, asphaltting)
- soil replacement.

Management of soil and exterior dusts may require a neighbourhood rather than an individual property focus. Periodic monitoring of cover will be required.

Strategies for other lead hazards will vary depending on the nature of the hazard and could include WorkSafe's involvement to reduce occupational take-home lead, replacement of plumbing fixtures to reduce lead in drinking-water, replacement of carpets, disposal of unsafe ceramics, cosmetics or (imported) canned food, or other strategies.

4. Educate the site occupiers that in most circumstances, abatement cannot be considered as a complete or permanent solution, but must be complemented by ongoing behavioural adjustments to reduce (remaining) exposure.
5. Behavioural strategies are essential accompaniments to abatement strategies, but may be used alone in some circumstances (see Summary of the graded response protocol). These strategies include:
 - house cleaning routines
 - personal hygiene practices

- dietary habits (refer to Chapter 5).

However, public health staff should be aware that education to change the daily behaviour of children, caregivers, visitors and so on, is very difficult to sustain long term.

House cleaning routines are designed for dust suppression, and will typically involve a high-efficiency particulate air (HEPA) filtered vacuum – common detergent – HEPA filtered vacuum cycle. The extent and frequency of house cleaning will depend on the level of source control achieved and ‘dustiness’ of the environment.

Hygiene practices refer to:

- personal care such as handwashing
- behavioural risk factors such as the extent of repetitive hand-to-mouth activity, nail biting, soil eating (pica)
- access to interior spaces by pets and (exterior) dusts
- use patterns, such as location of principal play areas, play activities and feeding practices.

These interventions are designed to limit exposure to interior settled house dust and outdoor soil (the usual reservoirs of lead), by changing the daily behaviours of the case, caregivers, other residents, visitors and pets.

As with any intervention, there may be unintended consequences. Caregivers need to understand that children’s play activities and locations should be respected within the bounds of safety. Age-appropriate mouthing is essential exploratory behaviour; children should not be punished for nail biting or thumb sucking. Caregivers should not indulge in unnecessary cleanliness and ‘dirt’ avoidance.

The extent of behavioural adjustment advice will depend on pre-existing household behaviours, household resources, the nature and severity of the lead exposure, and household composition. Typically, behavioural adjustments will need to be maintained (and kept age-appropriate) until the youngest child reaches six years of age.

Dietary modification can reduce absorption of ingested lead in young children from approximately 50 to 10 percent of ingested doses. A careful assessment of nutritional status, diet and feeding practices is essential. This should be conducted by or with a dietitian and the assessment may include blood tests to determine iron status. Risk and protective factors include:

- frequency of feeding
- fat intake

- phosphate intake
- intake of calcium, iron and zinc
- vitamin C intake.

Iron status is relevant not only because of its influence on lead absorption, but because of the interaction between iron deficiency and lead exposure on cognitive development. Iron deficiency is also a recognised cause of pica.

Stage 4: Risk reduction implementation

1. While the household has the ultimate responsibility for making and maintaining behavioural modifications (with the support of the public health team), responsibility for environmental abatement lies with the property owner (who may or may not be the occupier).
2. Ensure that the household (and property owner/landlord if different) participates fully in the development of the plan and feels 'ownership' of it. Recognise barriers to implementation of the plan and provide support as required to overcome them. Possible barriers include:
 - lack of information or understanding of what is required (and why)
 - lack of confidence in their ability to carry out the task
 - lack of feedback regarding progress
 - lack of financial or material resources needed to carry out the task
 - lack of motivation (eg, belief that lead exposure is not harmful or that recommended interventions are useless; low priority given to chronic lead exposure versus more acute threats to case or family health)
 - language or cultural barriers.
3. As well as attention to these barriers, successful implementation of risk reduction strategies requires:
 - maintenance of open and clear communication with the household (and other stakeholders) throughout the process
 - direct observation (and supervision if required) of at least the major interventions (environmental and behavioural) to ensure both safety (avoidance of unintended outcomes) and compliance
 - ongoing monitoring, evaluation and feedback (plus corrective action as necessary).

4. On rare occasions, cooperation from a household or landlord may not be forthcoming. Try to determine the underlying problem through supportive discussion. If previously unrecognised barriers to implementation can be identified and overcome, the situation may be amicably resolved.

If this is not possible, legal action may be necessary to ensure the safety of the case. Discuss this fully with the household (and their legal representatives if any) and the local authority. Options for enforcement of abatement include:

- action under the Health Act 1956
- action under the Building Act 2004.

Choice will depend on the circumstances of the case and the decision of the territorial authority which has duties and powers under the Health Act 1956. Section 124 of the Building Act 2004 provides territorial authorities with powers regarding buildings which are dangerous or insanitary. If the dwelling cannot be made lead safe by action taken under either of these statutes, a closing order under sections 42 or 44 of the Health Act can be issued to prevent occupancy by families with young children (refer to Chapter 6).

5. The owner of the building will require a building consent under the Building Act 2004 from the territorial authority for risk reduction (abatement) work involving any building work not exempt under the Act. The territorial authority should be consulted about work that may, or may not, require a building or resource consent (refer Chapter 6).

Stage 5: Risk reduction evaluation and monitoring

1. Clearance testing

Carry out clearance (post-abatement) testing if significant abatement work has been done. This will enable the short-term impact of the abatement to be evaluated. The timing of clearance sampling is important, as many abatement processes (such as paint removal) will generate transient increases in dust (and soil) lead levels. Collection of clearance samples should be delayed (or repeated) six weeks after completion of the work for this reason.

Post-abatement dust and soil lead loadings or concentrations may be compared with a standard 'clearance level' such as the US EPA values used in this guideline.

Provided samples are collected consistently, comparison of pre-abatement with post-abatement levels (before/after comparison) may have greater validity.

2. Based on this interpretation, decide whether it is safe to permit reoccupation (if the people concerned have been temporarily relocated to lead-safe accommodation).

This may require clearance testing immediately following the post-abatement clean-up, in which case a further round of clearance testing will be required six to eight weeks later. Also decide on any necessary changes to the risk reduction strategy, and plan any further evaluation and monitoring, in consultation with the household.

3. **Monitoring**

Depending on the result of abatement, liaise with the local authority about whether any other action needs to be taken.

4. **Serial blood lead monitoring**

While clearance and subsequent rounds of environmental sampling may provide useful information for monitoring and feedback, the key evaluation tool is serial blood lead measurement (which may be restricted to the index case or broadened to include other exposed residents, depending on the situation).

Blood lead is a biomarker that integrates exposures from all sources, across all media, and furthermore reflects exposure over the preceding three or four weeks more closely than cumulative exposure. As such it is ideally suited for use as an indicator of short-term trend in exposure. Nevertheless, prolonged chronic exposure will reduce the expected rate of fall of blood lead, because lead is mobilised from bones (ie, reduction of external lead source will be partially compensated by substitution of an internal source).

In many circumstances, a rate of fall in blood lead of more than 0.10 $\mu\text{mol/l/month}$ may not be achievable (without chelation, which may be clinically indicated for a case with a high blood lead level). As blood lead drops below 1.2 $\mu\text{mol/l}$, even this modest rate of decline may not continue.

Also, a transient rise in blood lead immediately following abatement is not unusual, reflecting mobilisation of environmental lead during the abatement process.

For these reasons, it is recommended that blood lead not be retested until at least six weeks (or three months for the 0.24–0.47 $\mu\text{mol/l}$ range) following completion of abatement/implementation of a behavioural risk reduction strategy.

Blood lead should then be tested again after six months and then annually until age six or until results fall below 0.24 $\mu\text{mol/l}$.

(If the case has been referred for paediatric assessment, or has received chelation therapy, the times and frequency of serial blood lead measurements will be coordinated by the paediatrician or physician.)

For children with a blood lead level below 0.48 µmol/l, the time needed for a decline in blood lead level in response to a public health intervention is unknown.

For higher blood lead levels, the time to reduce to below 0.48 µmol/l is months to years depending on the level and duration of exposure (Binns et al 2007).

It is important that the family have realistic expectations about the rate and extent of decline in the case's blood lead that can be achieved. Unless initial blood lead is dangerously high (over 2.17 µmol/l), a slow but reasonably steady decline to less than 1.2 µmol/l (and preferably below 0.48 µmol/l) will generally be sufficient to prevent any clinically detectable impact on growth or development (at the level of the individual case). A levelling out of the blood lead level over three to six months at levels over 0.24 µmol/l, or rebound in blood lead, would be cause for concern and re-evaluation.

Stage 6: Risk management

If serial blood lead measurements level out or rebound (or if serial environmental samples indicate recontamination), corrective action may be necessary.

1. Recheck compliance with behavioural protocols. (Is house-cleaning equipment functional? Are procedures fully understood?)
2. Recheck completeness and integrity of the abatement work already done.
3. Search for additional lead hazards (including unusual sources or pathways of lead exposure that may have been overlooked in the investigation stage).
4. Consider additional environmental sampling to pinpoint hazards and confirm (open) exposure pathways, and increase frequency of serial blood lead measurements (blood lead testing of other household residents and pets should also be reconsidered).
5. If an amenable cause can be identified, this may be corrected. On the other hand, it may become clear that extensive additional abatement work is necessary. This may be impractical (the necessary abatement work may cost more than the house itself), in which case the family will require permanent relocation in lead-safe housing. In this situation, the family will need to be counselled and supported. The public health case manager will need to liaise with the local authority and may need to advocate on the family's behalf with insurers, and Crown agencies such as Kāinga Ora – Homes and Communities and Work and Income New Zealand.

Chapter 4:

Risk reduction – abatement

Main points

- A management plan to reduce lead exposure in the home should incorporate both behavioural (educational) and environmental (abatement) strategies.
- Risk reduction strategies should be appropriate to the scale and significance of the exposure to lead.
- Removal of intact lead-based paint is not recommended – it only increases the hazard.
- The general principles for safe abatement should be followed.
- The affected household (and the building owner if different) should be involved in decisions on appropriate abatement strategies.
- In choosing an abatement method, ensure that the alternatives to the removal of the paint have been fully considered.
- When removing lead-based paint ensure that steps are taken to protect occupiers, workers and the environment from contamination.
- For small areas, wet scraping and wet sanding are the preferred methods. Chemical stripping can be used. Heat stripping is not recommended.
- Only power sanders that are fitted with HEPA filters should be used.
- Abrasive blasting should never be used on domestic premises.
- Debris from paint removal should be disposed of carefully and in accordance with any local authority requirements.
- Areas of contaminated soil can be covered over with a soft cover (eg, grass, bark chips), a hard cover (eg, paving), or removed and replaced, depending on the level of contamination.
- Where soil is removed and replaced, the replacement soil should have as low a lead concentration as possible, but not greater than 210 µg of lead/g of soil on a residential property.

Introduction

The goal of (safe) abatement of lead-based paint hazards is the long term, sustainable reduction of interior settled house dust lead loading, while minimising any transient (short-term) increase in environmental contamination with lead.

To achieve this goal, a set of general principles for safe abatement have been developed (adapted from US HUD 2012).

Principles of safe abatement

1. Identify and carry out essential repairs to components of the building that may further deteriorate and release leaded dust or compromise the integrity of abatement measures.
2. Carry out abatement activities so as to minimise the generation of leaded dust during the process.
3. Contain and safely dispose of all dust generated by abatement (as well as other abatement waste).
4. Protect occupants during the abatement (if necessary, temporary relocation of preschool children, pregnant women and pets, restriction of site access for those vulnerable groups until environment made lead safe).
5. Protect occupants' belongings during the abatement (preferably safe storage out of the house, or as a minimum dustproof cover for all furniture, furnishings, surfaces, clothes, utensils that may receive dust).
6. Carry out a thorough post-abatement clean-up (involving at least one cleaning cycle, ie, high-efficiency particulate air filter (HEPA) vacuum – common detergent wash – HEPA vacuum).
7. Facilitate ongoing dust suppression by occupants after abatement.
8. Complement source control and ongoing dust suppression strategies with hygiene and dietary routines to further reduce exposure to and absorption of lead.
9. Evaluate outcome by serial blood lead measurement. Carry out clearance testing (and further rounds of environmental sampling) as an additional evaluation/feedback tool if necessary.

Abatement strategies include:

- paint film stabilisation
- surface coating
- treatment of friction and impact surfaces

- paint removal
- enclosure (including sealing)
- building component replacement (including replacement of carpet and soft furnishings)
- soil cover (soft and hard)
- soil replacement.

These strategies vary in their effectiveness, appropriateness in different situations, requirement for ongoing maintenance, and cost. Whichever strategy or combination of strategies is selected, the building owner and the occupants should be fully involved in the decision. They should understand the cost implications (including the costs of essential repairs), the need for temporary relocation, the need for clearance testing prior to re-occupation, and the need for ongoing behavioural controls. Advice about accessing insurance or other financial support may need to be provided, and to obtain temporary lead-safe accommodation.

The abatement strategies described here are secondary prevention measures that need to be taken in the event of a person being exposed to lead. To help support primary prevention, the *Guidelines for the Management of Lead-Based Paint* were developed (Ministry of Health and Ministry for Business Innovation and Employment 2013). This document should be consulted for advice on primary prevention strategies (many of which are similar to secondary prevention interventions based around the investigation of a lead-exposed case).

Selection of contractors and materials

All paint removal, stabilisation and repainting should be carried out by reliable, suitably trained and experienced painting contractors certified by Master Painters New Zealand (MPNZ) in the management of lead-based paints. MPNZ arranges training programmes on the management of lead-based paint for their members, apprentices and the wider painting industry. Those that successfully complete the training are designated as ‘Lead Based Paints Accredited Contractor’ (hereafter called ‘accredited painting contractor’) and should be able to provide evidence of the certification upon request.

Contractors for other building work, such as enclosure, should be selected for reliability and experience and be aware of the lead hazards and protective measures required.

The success of several abatement measures (other than enclosure and component renewal) rely on new paint films. A paint system that is compatible with the existing paint film, exposure and use must be selected. The advice of paint manufacturers (who have responsibilities under the Consumer Guarantees Act 1993 and the Fair Trading Act 1986 regarding the advice given and claims made for products) should be sought on the most

appropriate complete paint system and methods to be used. Similarly, surface coating systems using specialist liquid coatings (if available as discussed later) should be chosen on the advice of specialist manufacturers.

Essential repairs

The first step in abatement is to ensure that existing or latent conditions that could undermine the success of the abatement work are corrected before work starts; in particular, attention is required to correct structural deficiencies, moisture problems, and surfaces that are difficult to clean.

Structural deficiencies, such as inadequate foundations and piles; inadequate, rotten or decayed structural timber in walls, floors and roofs; may permit movement in the structure (or provide inadequate fixing) and cause subsequent damage to abatement measures, especially those employing enclosure.

External moisture penetrating the building envelope will cause deterioration of the structure, floors and roofs as well as the building's external cladding and interior lining. Moisture penetration from the ground and through walls and roofs will compromise all abatement measures, as well as being a potential cause of environmental conditions that are harmful to health. Attention should be paid to every cause of dampness that should be corrected including, conditions on the site and around the house, under-floor moisture and ventilation, damp-proof courses, external cladding (moisture in weather boards should not exceed 14 percent if paint film failure is to be avoided), windows and glass, roof leaks, chimney caps, gutter and downspout problems, roof flashings, external cover strips and trim, missing or damaged external doors, joint sealants, and window and door fastenings.

Other sources of dampness should be eliminated that may be caused by internal plumbing leaks, blocked or defective drains, failed linings and sealants around showers, basins, baths and sinks.

Surfaces that are very difficult to clean should be renewed or covered with easily cleaned material whether or not they generate lead dust themselves.

Consideration should be given to necessary rewiring or plumbing remodelling before abatement work starts because subsequent disturbance of the internal lining of the house may cause lead hazards to recur.

A decision whether to proceed with essential repairs and subsequent abatement of lead-based paint hazards will depend on the location, age and condition of the building, its siting in relation to natural hazards (eg, flooding), the cost of essential repairs, the extent of the paint and any other lead hazards, the economic life that may be expected in the light of these factors, and the present and future values of the property.

In many instances a lead hazard arises during renovation of an older property where the economics of renovation are favourable and the essential repairs are likely to be planned and budgeted for anyway. When enclosure is chosen as the preferred method of abatement there are opportunities to incorporate other benefits such as improved insulation (eg, the use of insulated external cladding), improved durability and aesthetics.

Other situations may arise where the property is very run-down, poorly located (or subject to flooding) and uneconomic to renovate. In such a circumstance a careful decision is required by the building owner before embarking on repairs and abatement that may prove uneconomic. Rehousing the occupants will become a priority and demolition of the building, with suitable precautions to prevent lead contamination of the site and surrounding areas, would be preferable to it remaining standing and presenting a growing hazard with further decay and becoming an attraction to illegal occupation. Close cooperation with the territorial authority would be needed in such circumstances.

Paint film stabilisation

The objective of paint film stabilisation is to prevent existing lead-based paint layers from deteriorating further and releasing more lead into the building environment. It is a process akin to normal repainting but with extra care and thoroughness. It is likely to be the abatement measure of least initial cost, but ongoing monitoring and a probable life of less than 10 years may not make it the least cost solution in the long run. If the existing lead-based paint film (even though chalking) and the underlying paint layers and substrate are sound and well bonded together stabilisation should be considered.

Paint film stabilisation is appropriate where:

- a life of the abatement measure of less than 10 years is appropriate
- regular monitoring of the integrity of the stabilised surface is practicable
- the substrate supporting the paint film is sound and will not be subject to deterioration and dampness (following essential repairs if necessary)
- the paint film is adhered well to the substrate and unlikely to become poorly adhered
- the surface is unlikely to be chewed or damaged by impacts or wear and tear.

Lead-based paint is oil-based almost without exception. As it ages it becomes hard, usually glossy (unless outside where it may be chalking), of low permeability, and inflexible. Accordingly, the paint film is vulnerable to failure from moisture in the form of water or water vapour under the paint film, expansion and contraction of the substrate, and factors producing poor adhesion to the substrate (including layers of wallpaper under the paint). If any of these conditions are present, paint film stabilisation is inappropriate and,

because the paint film is failing (or there is risk that it will do so), it should be regarded as an actual or potential source of lead that may need to be abated using other methods.

In many instances, lead-based paints will have been painted over already and, if former preparation has been inadequate, the subsequent coats may be peeling off. If the peeling coats can be removed safely and the underlying lead-based paint is sound, paint stabilisation may be a satisfactory option.

Roofs have been identified as a contributing source of soil lead around the house (and a potential source of lead contamination of water if a roof water supply is used). Paint film stabilisation may be a satisfactory option if water is not collected.

When advising on paint film stabilisation the health protection officer should consider a number of factors.

Suitability

Confirm the suitability of the existing surface for stabilisation by adhesion tests for adhesion to underlying coats of paint and the substrate using adhesive tape (press on firmly about 100 mm of wide adhesive tape, wait a few seconds and pull off; contain and dispose of carefully). Where deterioration is evident carry out one or two tests on each square metre; otherwise one test each 5 square metres will suffice. If poorly bonded areas exceed some 10 percent of the total area (requiring paint removal over those areas), or the condition of the substrate will not be rectified by essential repairs, other abatement methods should be considered.

Identify all areas that require other abatement measures (eg, friction and impact surfaces, surfaces that may be chewed or subject to heavy wear, or roofs used for the collection of water).

Essential repairs

Identify all essential repairs to remove factors likely to cause subsequent failure of the stabilised surface.

Contractors

An accredited painting contractor should be selected by the building owner. Essential repairs will require the services of a building contractor first.

Surface preparation

Surfaces will need to be prepared by washing, wet sanding and scraping to remove dirt, grease, mould (spores need to be killed by proprietary mould inhibitors), remnants of cleaning solutions, loose paint patches and surface gloss and, in the case of chalking surfaces, pigments (principally lead-based) that have become free from the paint film binder. If timber has a moisture content of more than 14 percent, the impermeable layers of old paint may be forced off by water vapour. Precautions should be taken to prevent water entering the end grain of timber during surface preparation. The procedure requires the same precautions as those described later for paint removal to protect occupants, workers and the environment although the amount of lead-based material released and removed will be considerably less. This is the stage causing the greatest lead hazard.

Paint system selection

A paint system that is compatible with the existing paint film, exposure and use should be selected with the advice of a paint manufacturer. A total dried paint film thickness of no less than 2.5 mm is required (US HUD 2012). The manufacturer should be provided with all relevant information about the job and asked to advise on the required coverage (m²/l of paint) to obtain adequate dried film thickness. All paint should be selected to provide outstanding adhesion, durability, chemical resistance and flexibility.

Application of the paint system

Spot priming is required of all areas where bare wood or metals are exposed after preparation using suitable primers for wood, zinc coated surfaces or other metals (including treatment of rust) following the paint manufacturer's recommendations.

Apply specified undercoat and topcoats at the recommended coverage and within the times recommended to ensure good bonding between coats (and curing in the case of acrylic paints) and the avoidance of dirt and salts (in coastal areas) being deposited on paint surfaces between coats.

Protection and clean-up

Conduct thorough clean-up (standard cleaning cycle), especially if any paint removal was required.

Monitoring

Plan how monitoring of the stabilised paint film will be carried out. As a minimum (assuming lead dust levels are below clearance levels) it is suggested that the owner

should carry out annual visual inspection and contact the health protection officer if necessary. Paint film life can be extended considerably by annual inspection and maintenance. The owner should be encouraged to carry out checks and have work done (spot wet scraping, spot priming and repainting). Independent inspection is recommended at six months, to verify that the stabilisation of the paint film is not showing signs of early failure, and then at years five, eight and ten. If the paint film is still sound at ten years, inspections should continue at, say, two-year intervals especially if there are children under six years old in the house.

If restoration measures (including further essential repairs) appear insufficient to provide a continuous and well-attached paint film, the complete process should be repeated or, if the method is proving unsatisfactory, alternative abatement methods should be considered.

Surface coating

Surface coating is defined as the process of making a lead-based paint hazard inaccessible by providing a robust flexible barrier between the lead-based paint and the surface. The barrier is formed using a liquid-applied coating, or a covering material bonded by adhesion to the existing lead-based paint film. It is therefore highly dependent on the integrity of the existing surface for its performance.

Surface coating technology using special liquid coatings is reported as used less often than other abatement methods in the United States (US HUD 2012). The US HUD guidelines also note that the disadvantages of this abatement method appear to have outweighed the advantages in many cases. At present, the paint manufacturers consulted in New Zealand are not confident that surface coating using liquid coatings is a satisfactory option or that they could offer liquid coatings for surface coating that met the intended purpose.

Surface coating may be appropriate where:

- a life of the abatement measure of 20 years is sought
- regular monitoring of the integrity of the coated surface is practicable
- the substrate supporting the existing paint film is sound and will not be subject to deterioration and dampness for the next 20 years (following essential repairs if necessary) and be capable of supporting the weight of the surface coating layer
- the existing paint film is very well adhered to the substrate and unlikely to become poorly adhered
- the surface is unlikely to be chewed or damaged by severe impacts or excessive wear and tear.

Surface coating should be differentiated from **enclosure**, in which the barrier is rigid, is mechanically fastened to the substrate and does not depend on the integrity of the existing paint film for its performance. It should also be differentiated from **encapsulation**, in which the paint is isolated or enclosed on all sides.

Surface coating depends on a successful bond between the surface of the existing paint film and the coating. In addition, all layers of the existing paint film must adhere well to each other, and the innermost layer must adhere well to the base substrate. All the prerequisites for paint film stabilisation apply to surface coating but, because the surface coating layer is thicker, heavier and more costly than paint, the risk (and the cost) of failure is greater.

Surface coating, therefore, has only limited application as an abatement technique, and can be used only when the nature and condition of the existing paint film and substrate allow. Surface coating is unsuitable for friction and impact surfaces.

Canvas-backed vinyl wall coverings attached by heavy-duty adhesives (occasionally used in commercial situations) would be suitable as a surface coating but may be difficult to obtain. Heavy-duty vinyl wall coverings (paper base with a bonded heavy-duty vinyl layer) attached by heavy-duty adhesives is readily available and may be applied by experienced decorators; a life of 20 years could be obtained under conditions without heavy wear. In suitable locations, tiles (eg, ceramic, vinyl, faced hardboard) or other materials secured by adhesives may be considered as suitable surface coatings. Specialised liquid coatings and reinforced liquid coatings may become available but should only be used if supported by firm guarantees from a manufacturer.

Sealing of wooden floors with a polyurethane coating to create a smooth, easily cleaned surface may also be regarded as a form of surface coating. This is particularly important for tongue-and-grooved or wood block parquet floors, because such surfaces are otherwise very difficult to clean adequately. (Wood board floors that are not tongue-and-grooved may present gaps that collect dust that cannot be removed satisfactorily and coating with glued and pinned hardboard with a suitable decorative and wearing surface such as vinyl tiles may be necessary.)

When advising on surface coating, the health protection officer should consider a number of factors.

Suitability

Confirm the suitability of the existing surface for surface coating in a similar manner for paint film stabilisation. If poorly bonded areas exceed some 10 percent of the total area (requiring paint removal), or the condition of the substrate has deteriorated and will not be rectified by essential repairs, other abatement methods should be considered.

Identify all areas that require other abatement measures (eg, friction and impact surfaces, surfaces that may be chewed or subject to very heavy wear).

Essential repairs

Identify all essential repairs to remove factors likely to cause subsequent failure of the surface coating.

Contractors

A reliable and suitably trained and experienced contractor should be selected by the building owner.

Surface coating system selection

Surface coating of internal surfaces using tiles (of various types), and heavy-duty vinyl wall coverings need to be appropriate for the exposure (eg, may be unsuitable above sinks and basins) and use of the area. Adhesives must be compatible with the existing paint film, and an assessment should be made whether the existing paint film can support the weight of the surface coating.

If liquid-applied surface coatings are available, the advice of alternative surface coating manufacturers should be sought for a complete systems and methods of application. Establish whether repairs to liquid applied systems are feasible and whether specialists would be required. The manufacturers should be provided with all relevant information about the job and asked to advise on the required film thickness suitable for the location in the house and the desired life of the system. All systems should be selected to provide outstanding adhesion, durability, chemical resistance, flexibility and ease of cleaning. A decision will be required on which system is most suitable and offers the best warranty. Field patch tests are advised to confirm compatibility with existing paint films, the ability of paint film to support extra weight, and the adequacy of surface preparation methods.

Surface preparation

Preparation is generally similar as that for paint film stabilisation, but specialist coatings manufacturers may require their own specification to be followed.

Application of the surface coating system

Ensure that manufacturers' recommendations are followed, especially with regard to thickness of specialist liquid coatings (thickness gauges are available). For tiles and other

coverings ensure complete coverage of the lead-based paint and sealing of gaps. Edge and corner protection will prolong the life of such surface coatings.

Protection and clean-up

Conduct thorough clean-up (standard cleaning cycle), especially if any paint was removed.

Monitoring

Plan how monitoring of the surface coating will be carried out. Monitoring frequency should be adapted if lead dust levels remain close to or exceed the clearance levels. As a minimum (assuming lead dust levels are below clearance levels) it is suggested that the owner should carry out annual visual inspection and contact the health protection officer if necessary. Any failure of specialised systems should be reported to the manufacturers and/or applicators and remedies sought under warranty or the Consumer Guarantees Act 1993. Maintenance of simple surface coating systems such as heavy-duty vinyl wall coverings or tiles may extend their life and be carried out by appropriate contractors. Maintenance of specialist coatings may need to be done by the manufacturer or the applicator. Independent inspection is recommended at six months (to check that the surface coating system is not showing signs of early failure) and subsequently at five-year intervals.

If specialised restoration measures appear insufficient to provide a continuous well attached and robust surface coating the complete process should be repeated or, if the method is proving unsatisfactory, consider alternative abatement methods.

Treatment of friction and impact services

Friction surfaces are those surfaces subject to abrasion which may liberate leaded dust. Examples are window and door surfaces that rub together on opening and shutting, cabinet doors and drawers, stairway treads and railings, and floors (including exterior decks and porches).

Impact surfaces are generally protruding surfaces prone to being banged or bumped, thus causing small chips of lead-based paint to fall to the floor. Most common impact surfaces are doors, door jambs and architraves, skirting boards, stair tread edges and risers, edges of sills and shelves and chair rails. Other surfaces may be banged by young children, including cots, toys and furniture.

Movement and settlement in the building may have reduced clearances between doors and window sashes and their frames, or dampness may have caused swelling of timber.

Essential repairs to correct or prevent further movement is a first step in addressing some problems with friction surfaces.

Windows may be the largest source of lead dust from abrasion and chips, because paint tends to deteriorate faster under conditions of temperature variation, condensation and sunlight. Vertical sash windows, in particular, have sliding surfaces that are abraded. This is why the window trough (the portion between the lower surface of the sash and the sill) tends to accumulate high surface loadings of leaded dust. Vertical sash windows therefore require more critical attention than side or top hung window sashes.

Each surface subject to abrasion or impact damage needs to be considered individually because some may require treatment of the surface, others may be best protected from impact by enclosure or surface coating, and others will be best removed and replaced.

When advising on the treatment of friction and surface impact, the health protection officer should consider a number of factors.

Surfaces subject to friction and impact damage

Look for the most likely friction and impact surfaces around doorways, including doors, doorstops, hinges, door jambs, head and threshold. Impacts from door slamming may have dislodged paint from adjacent surfaces of architrave, skirting or walls. External doors may be binding because of dampness.

Around windows, examine the sashes (vertical or horizontal sliding, and side or top hung), sills, jambs and head. Windows may be binding because of dampness due to failure of the paint film, defective flashings and sealants, or other building defects.

Inspect stairway risers, tread nose, string, balusters and hand rail. Examine skirting boards and other timber mouldings, and painted floors.

Externally, examine building corners, veranda posts, balustrades, steps and other surfaces that are knocked or rubbed against.

Make a note on the plan of friction surfaces and areas of impact damage involving lead-based paint.

Essential repairs

Identify all essential repairs to remove factors causing poor fit of doors and windows, and dampness in timber.

Contractors

Essential repairs, carpentry work, and enclosures will require a suitably trained and experienced building contractor to be selected by the building owner. Other treatments will require an accredited painting contractor.

Treatment of windows and door systems, furniture and fittings

If the window sashes or doors are binding in their frames they will need to be removed and eased (preferably off-site) by wet planing. Other friction or impact-damaged surfaces of these items should preferably be stripped chemically (off-site) or misted and scraped back to bare wood and repainted, carefully following the advice in the next section, Paint removal.

Other friction and impact surfaces that cannot be removed easily for treatment, and where renewal would be an expensive option, should be misted, scraped and wet-sanded back to remove sufficient old paint to reduce the probability of future damage or abrasion (eg, tight window sashes), and then repainted with a paint system recommended by a paint manufacturer. Alternatively, some surfaces, such as the window trough of a vertical sliding sash window, and door thresholds may be capped with sheet metal (back caulked) or otherwise enclosed. Components such as internal sills that are often a favourite edge to be chewed should preferably be removed and replaced.

If windows and doors are in very poor condition and renovation of the property is economically viable, replacement may be the more satisfactory and practical option. Consider, at least, the renewal of windows and doors in children's bedrooms and rooms where they frequently play.

Any other items that can be removed from the house that have friction surfaces or are subject to impact damage (eg, drawers, furniture, cupboard doors) should preferably be chemically stripped off-site and repainted.

Treatment of stair systems and skirtings

Coverings providing enclosure are generally the most practical for stairs. Rubber tread guards can be used to cover the entire width of the stairs, with metal nosing, if necessary, and plywood or high-density hardboard nailed to the risers. The fit must be tight and a strip of sealant applied to the edges of the coverings before fixing. Stair strings and skirtings may be similarly enclosed or, especially if skirtings have rot or borer damage, renewed.

Balusters and handrails may be amenable to treatment by paint film stabilisation, but if impact damage is serious the replacement of the components would be the preferred

course. Paint removal is the least desirable method unless only a small area requires treatment and all the precautions in the next section on Paint removal can be met.

Treatment of porches, verandas, decks, interior floors, exterior corners

These areas can receive use that creates significant amounts of paint chips and dust from abrasion and impact. As a minimum abatement measure, lead-based paint should be carefully stabilised using high-quality paint selected for wear and chip resistance.

Painted interior floor surfaces subjected to abrasion and impact damage should preferably be enclosed with plywood, hardboard or particle board and covered with a decorative wearing surface such as vinyl tiles. The enclosure sheets should be pinned and back caulked at the edges with a flexible sealant. Some heavily impacted surfaces such as veranda posts, steps or external corners of walls may be enclosed in treated wood or plywood, and corner mouldings or metal cover strips used on external corners.

Protection and clean-up

Conduct thorough clean-up (standard cleaning cycle), especially if any paint removal was required.

Monitoring

Plan how monitoring of the treated friction and impact surfaces will be carried out. Monitoring frequency as suggested for paint film stabilisation would be appropriate in most cases.

Assess the condition of the treatment work in a similar manner to that for paint film stabilisation, surface coating, or enclosure.

Paint removal

Paint removal means the separation of (non-intact) paint from its substrate, either on, or off-site.

On-site paint removal inevitably creates hazards from dust generation. In addition, paint removal (whether carried out on-site, or off-site) seldom removes all lead particles from porous substrates such as wood. Instead, a lead residue will generally be left on or near the surface, which may leach into new paint or otherwise become available once again to susceptible children. Paint removal also imposes the highest operator risk of any abatement method, and can create significant waste disposal problems. For these

reasons, on-site paint removal is not a preferred abatement method, and alternatives should be used when possible. As considered above, off-site paint removal by chemical stripping is a practical option for removable building components, furniture and fittings where renewal would be too costly.

If paint removal is to be done, it should be restricted to limited areas, and carried out as safely as possible. The extent of preparation, choice of removal technique, occupant and worker protection, clean-up, and maintenance will depend on the scope and scale of the job.

Reference should be made to the later section on Protection during abatement, at the end of this chapter, because this is especially important during paint removal.

The following provides general guidance to the health protection officer advising on a paint removal job.

Choice of abatement method

Ensure that alternatives to paint removal (especially enclosure and building component removal) have been fully considered.

Occupant protection

Ensure that occupants (especially preschool children, pregnant women and pets) will not be exposed to any hazard arising during the paint removal work. This will mean temporary relocation is recommended, unless the job is very small. As a minimum, children must be kept well away from the work area. Access restrictions must operate at all times, not just during working hours, until final clean-up has been done and the site is considered safe.

Choice of contractor and worker protection

The building owner should select an accredited painting contractor. Ensure that the contractor (as the employer) and the employees fully understand the hazard of lead dust and fumes (including the risk of occupational take-home lead), as well as the hazards associated with the paint removal method(s) to be used.

Environment protection

For interior paint removal, seal windows, doors, ventilators and other openings with adhesive tape to ensure that any dust generated does not leave the room. Remove all soft furnishings (including curtains and carpets where possible), furniture, utensils, food and medicines from the room (to lead-safe storage).

Install disposable polythene covers, taped down as required, to prevent paint fragments and dust contaminating the floor and any remaining carpets and fittings.

For exterior paint removal, seal windows, doors, ventilators, eaves and other openings of all nearby buildings into which dust from the work area may escape. Place disposable polythene sheeting as a groundsheet beneath the work area, to prevent paint fragments and dust from contaminating soil, vegetation or paved surfaces. Avoid working when wind or draughts could cause dust and debris to be blown away from the work area.

(Disposable polythene sheeting is recommended, because washing will not remove all the dust from sheeting; reusable sheeting may become a source of lead contamination rather than a containment device.)

Choice of paint removal method

For small areas, manual wet scraping followed by wet sanding is the preferred method. Use a spray bottle attached to the scraper to keep the surface wet while scraping. Apply enough water to moisten the surface completely. Do not use wet methods near electrical circuitry.

Manual dry scraping and sanding will generate significant amounts of lead dust; however, in very limited areas near electrical circuitry, this method may have to be used.

Power sanding will generate a large amount of fine lead dust and should be avoided. If a relatively large area is involved, however, there may be few alternatives. In that case a power sander fitted with a HEPA exhaust must be used. The shroud or sanding head (depending on the type of tool) must be firmly applied to the surface at all times, even then dust collection may be incomplete.

Heat guns operating above 450°C, or any form of open flame burning (such as LPG or blow torches) will generate lead fumes. These very small lead particles cannot be contained and may cause widespread environmental contamination. Such methods should not be used.

For small areas, an electric heat gun operating below 450°C may be used to loosen the paint, but this will need to be followed by dry scraping and sanding, so will share the disadvantages of the latter method.

Water blasting may be an acceptable method for exterior use. There are two problems with this method; high-pressure water can raise the moisture content of timber cladding above 14 percent leading to subsequent paint film failure (especially if there is wholesale paint removal), and the contaminated waste water will require treatment before it is released in a manner approved by the territorial authority and/or regional council. Note that

water blasting will inevitably create some degree of environmental lead contamination, however carefully attempts are made to collect the water and cover soil or vegetation.

Sandblasting (abrasive blasting) should never be used in residential environments. It generates large amounts of lead dust that cannot be contained.

Chemical paint removal methods are preferred for jobs too large, or otherwise unsuitable, for manual wet scraping (and will always be used for off-site paint removal). Various chemical strippers are available, and fall into two groups: alkali and non-alkali. Whichever stripper is used, the manufacturer's instructions must be followed. This will usually include the use of a respirator fitted with an appropriate cartridge. Apply the chemical in accordance with the manufacturer's instructions on the label and wait the full period of time recommended. Remove the loosened paint in as large size pieces as possible using a sharp tool. With all chemical strippers, the manufacturer's instructions on the label should be read before commencing, and followed closely.

Clean-up

Accumulated dust and paint debris should be removed as often as necessary to ensure containment – as a minimum, at the end of each work day.

After gross debris removal, a HEPA-filtered vacuum cleaner should be used to remove dust (visible and invisible) from the work area and surroundings. Particular attention should be paid to ledges, windows and walls. This should be followed by wet mopping the surfaces and sheeting with a common detergent wash, to dislodge and aggregate resistant lead particles. These particles should then be collected by a second HEPA vacuum, completing the cleaning cycle.

At completion of the paint removal work, the cleaning cycle should be repeated twice.

Disposal

Debris should be carefully bagged and disposed of by co-disposal in a sanitary landfill that accepts low-grade toxic waste. You should liaise with your council about appropriate disposal. Used polythene sheeting, cloths, mops and vacuum bags should be sealed and disposed of in the same way. The territorial authority should be contacted for advice on acceptable disposal options.

If soft furnishings, such as carpets, have been contaminated (despite covers) they should undergo thorough off-site commercial cleaning. If heavily contaminated, there may be no option but to dispose of them. Affected layers of soil and vegetation may likewise need to be removed and replaced if they have become grossly contaminated.

Equipment (including cleaning equipment) can also spread contamination from one site to another and must be thoroughly cleaned of dust and paint fragments before it leaves the work area. A HEPA vacuum followed by a wet wipe and a second vacuum is recommended.

Re-evaluation

Paint removal is a permanent abatement method. Re-evaluation of the hazard itself is not required (provided all paint has been removed).

Enclosure

Enclosure is defined as the installation of a rigid (or semi-rigid), durable barrier that is mechanically fastened to the underlying (lead-based paint coated) building component, with all edges and seams sealed with an appropriate sealant.

Enclosure is appropriate where:

- a near-permanent abatement measure of more than 20 years is appropriate
- less onerous monitoring (compared with other abatement methods) is desirable
- the building structure has undergone all essential repairs before the enclosure is fixed and is very unlikely to require further repair that could disturb the enclosure within 20 years
- the surfaces to be enclosed are, generally, flat and unobstructed by mouldings and present the easy fixing of sheet material.

Surfaces with lead-based paint are enclosed to prevent exposure to these hazards; the enclosure must therefore be dust-tight. Unlike surface coating, the enclosure does not depend on the painted surface of the substrate for its durability but is mechanically fastened to the underlying building components. Enclosure differs from ordinary construction in that all edges, joints, seams and holes must be carefully sealed to create a dust-tight system.

If the underlying building components are structurally sound and there is no damp penetration or other defects (and therefore no repair is required), little dust should be generated by the enclosure process. There is little or no hazardous waste to dispose of, and the work is relatively permanent with little monitoring required. For these reasons, enclosure is the preferred abatement option, particularly for broad surfaces such as walls, ceilings, floors and exterior cladding. Difficulties do arise, however, where enclosure materials meet existing skirtings, architraves, window surrounds and fascias. Enclosure also involves a risk that future generations of occupants may be exposed to lead once

again through remodelling activities that break through the enclosure, or failure of the enclosure as a result of water damage or other reasons.

A roof presenting a lead hazard from which water is collected for drinking would be best dealt with by enclosure using new roofing material.

The following provides general guidance to the health protection officer advising on an enclosure job.

Suitability and structural integrity of the underlying building components

Check the structural integrity of the building components that are needed to support the enclosure. Any unsound structural member will need to be repaired if it is needed to support the enclosure.

Structural repairs may involve paint or plaster removal, or component replacement. Precautions relating to these processes will therefore apply.

If the substrate is sound but the (lead-based) paint is deteriorated, obviously no attempt should be made to stabilise or remove the deteriorated paint before enclosure (to do so would be to destroy the purpose of enclosure).

Consider the advantages that may be obtained (especially with external enclosure) to improve insulation, durability, weather proofing of the building envelope, and appearance.

Identify the other building components that may have to be disturbed (removed and re-fixed or replaced) and whether they present a lead-based paint hazard.

Essential repairs

Identify all other essential repairs to remove factors likely to cause subsequent failure of the enclosure, particularly building movement and moisture penetration from external and internal leaks.

Contractors

A reliable and experienced building contractor should be selected by the building owner. Although the skill required to fix enclosures can be provided by normal competent builders, extra care and understanding is required regarding sealing of the enclosures and lead hazards that may arise during the course of the work.

Choice of enclosure material

Any appropriate, durable, rigid or semi-rigid construction material can be used. For ceilings and interior wall lining, plaster board, particle board, plywood, fibreboard, wood panelling, laminated sheeting and other drywall linings, are all satisfactory products. The provision of a vapour barrier under the enclosure is desirable because it prevents water vapour generated in the house from passing into the cavity and condensing on uninsulated external wall surfaces.

Practical problems arise where enclosures meet existing skirtings, architraves and other mouldings. Plaster board may be too thick to sit comfortably against existing mouldings and may require their removal and replacement. Thinner enclosure material, such as 4.75 mm hardboard, helps to overcome such problems but may produce less even surfaces for decoration.

Externally, cladding can be enclosed with a variety of products including new timber, uPVC or aluminium weatherboard, brick cladding (requiring ties secured to adequately strong framing), or fibre-cement sheet. Insulated cladding composed of 40 mm expanded polystyrene sheet covered and sealed with a skin of glass fibre mesh and special mortar provides a light weight and insulating external cladding. (The specifications of such systems require flexible sealants at all exposed edges.) Roofs may be enclosed with new long-run steel (in preference to metal tile systems that would seem to provide greater opportunities for dust escape).

Floors can be enclosed with sheet material, such as hardboard, mechanically fixed to the existing floor as a substrate for tiles, linoleum or vinyl products. Particle board or plywood are alternatives.

Enclosure for windows is generally not a practical solution. Replacement, either of the complete window, or of the sashes only (avoiding the abatement of lead-based paint on glazing bars and other moulded surfaces) is a better approach. Aluminium window manufacturers provide a number of alternatives. Limited enclosure is possible, for example of window troughs, as discussed under the treatment of friction surfaces. Door surfaces may be enclosed with sheet material, but it is impractical to enclose the door edges, frames and stops. Replacing complete door sets is preferable.

Mechanical fastening

Although adhesives may be used as an additional fastening method, reliance should not be placed on adhesives alone. Instead, mechanical fasteners (such as screws or nails) penetrating to the underlying building structure should be used (instead of, or in addition to, adhesives) to anchor the enclosure material.

Sealing

The key to success for any enclosure system is the creation of a durable, dust-tight seal. This is particularly important because (lead-based) paint deteriorates more quickly behind an enclosure.

All edges, joints and seams of the enclosure – especially the bottom edge – must be properly sealed. Enclosure with plaster board properly completed with stopping compound will normally be adequate. Other materials will require high quality adhesive and flexible sealants, especially if any movement of building components is anticipated. Sealing must also be carried out where pipes or wiring penetrate the enclosure system. A variety of suitable adhesive caulks and other sealants are commercially available. External enclosure with weather board (of various materials) and new roofing will not provide adequate sealing of the underlying surface on its own and a breathable building cloth or reinforced under-cloak of strong building paper with all joints and edges sealed should be fixed first. The use of insulated wall cladding with its monolithic and well-sealed surface provides several advantages.

Protection and clean-up

Particularly if substrate repair is involved, some leaded dust may be generated. Appropriate measures to control, contain and collect dust must therefore be used. Generally, this will involve disposable polythene sheeting around the work site, collection and bagging of any gross debris, and a HEPA vacuum – common detergent wash – HEPA vacuum cycle at completion of the work.

Polythene sheeting, debris bags, vacuum bags and mop heads should be safely disposed of. Waste may simply be bagged and put out with the household refuse, if small in quantity. Otherwise it will need to be disposed of by co-disposal in an appropriate landfill.

Warning label

A warning to later renovators in the form of an indelible sticky label or stencil should be applied once the work has been completed. A suitable warning label would be (include date):

Caution: this structure encloses a lead-based paint hazard. Contact your local health protection officer or WorkSafe before carrying out any work.

Homeowners should also be encouraged to ask their local council to add a record of any potential lead-based paint on their property file.

Public health officers should also consider providing information to the relevant local council about lead paint hazards or mitigation measures recommended or undertaken regarding specific properties in appropriate circumstances. For example, if public health staff think the presence of lead-based paint may pose a health risk to future property owners or occupiers and the owner is not willing to consider recommended mitigation measures or provide warnings to future owner/occupiers.

Ultimately it is the local council's decision about whether to place any such information on the property file (or whether to include any such information on documents such as land information memoranda (LIMs) or project information memoranda (PIMs) that it produces for any applicant.

The roles of local councils and public health officers are further described in chapter 6. This includes potential compliance and enforcement options under the Health Act 1956 and the Building Act 2004.

Monitoring and re-evaluation

Enclosures should be inspected after six months to verify that no unexpected early failure is occurring. Thereafter, and providing the building structure remains sound and free from moisture penetration or leaks, the building owner should visually inspect the integrity of the enclosure annually. Independent inspection is suggested 10-yearly when the integrity of the enclosure should be evaluated and the general condition of the building assessed, especially for factors that could compromise the enclosure.

Building component replacement

Building component replacement is defined as the removal of windows, doors, architraves, skirting boards, trim and other building components that contain lead-based paint hazards. Usually, the item will be replaced by a new lead-free component.

The definition may be expanded to include the removal of heavily contaminated carpet, furniture and other items (which may be replaced with lead safe items, or not replaced at all).

Component replacement is a permanent source control (elimination) measure, and can generally be carried out with little environmental contamination arising. Moreover, it has spin-off benefits such as energy saving (eg, new draught-proof windows) and improving the longevity and value of the property. However, some components cannot be removed. Component replacement is particularly attractive in situations where remodelling work is already being done, and it is possible to integrate component replacement into the building rehabilitation programme at (relatively) little additional cost. It should not be assumed that

component replacement is always the most costly option, as the labour cost of other abatement options can potentially be higher. For example, the cost of correcting binding window sashes, repair of rotted sills and defective flashing, treatment of impact surfaces on internal sills, and the removal of paint and re-painting may exceed a replacement with an aluminium window.

The following provides general guidance for the health protection officer advising on a component replacement job.

Contractors and worksite preparation

A reliable and experienced building contractor should be selected by the building owner. Besides being competent in the building work, the contractor must be aware of the lead hazards that could arise.

The extent of preparation required will depend on the size of the component to be removed, its state of deterioration, and the ease of removal.

In most situations it will be sufficient to cover the floor adjacent to the site with disposable polythene sheeting and remove the furniture from the room.

Removal process

Use a garden sprayer to mist down the component with water (for dust suppression). Do not use water near electrical circuitry.

Score all affected painted seams with a sharp knife (this will provide a ready space for a pry instrument while minimising paint chipping during removal).

After cutting through any screws or other mechanical fasteners, use a flat pry instrument to carefully pry the component away from the surface to which it is attached. Try to keep the component intact and avoid chipping paint or generating/ disturbing dust.

Bag the component if badly deteriorated, prior to disposing of it (in a landfill).

Removal of the component may reveal visible (leaded) dust underneath or behind it. Preparation of the area to accept the replacement component may also release accumulated dust. In either case, dust should be collected without delay via one or more HEPA vacuum – common detergent wash – HEPA vacuum cycles. Mops or cloths and vacuum bags should be (double) bagged and disposed of with household garbage or directly to landfill.

Protection and clean-up

After installation of the replacement component (if any), the polythene sheeting should be bagged and disposed of to a landfill and the room subjected to a final HEPA vacuum – common detergent wash – HEPA vacuum cleaning cycle.

Monitoring and re-evaluation

Component replacement is a permanent source elimination measure, and requires no re-evaluation.

Soil cover

Soil abatement may be considered as an adjunct to paint/dust abatement strategies, but generally is of limited value (Weitzman et al 1993; Yeoh et al 2014) as the greatest influence on blood lead is dust and not soil. A range of soil abatement options is available:

- grass or other soft cover such as bark chips (analogous to surface coating)
- paving or other hard cover (analogous to enclosure)
- soil removal and replacement (analogous to building component replacement)
- raised garden beds
- remove and replace sand in sandpits.

The choice of soil abatement strategy (if any) will be based on the risk assessment. The key variables are:

- soil lead concentration (and bioavailability)
- location and use pattern
- condition of existing surface cover (if any).

If the ground cover is poor (ie, there are patches of bare soil exposed) at a particular location, reasons for this should be determined, because this will influence abatement method selection. Bare soil is commonly exposed in:

- heavily used play areas
- pathways
- areas shaded by buildings or trees.

In all situations, gross contamination (visible paint chips) should be removed. The area may then be covered with 25 mm of turf, 50 mm of bark chips, paving, raised garden beds or similar.

Usually, this will involve removal of some surface soil or a partial grass cover, to prepare the surface for the laying of turf or bark. This may temporarily increase the amount of bare contaminated soil potentially accessible to a child, or available to contribute by wind transport or tracking to interior surface dust. Care should be taken to minimise disturbance to the soil, and to contain, collect and safely dispose of any soil that has to be removed.

Behavioural adjustments to relocate outdoor play areas, reduce soil ingestion, and minimise soil transfer and tracking into the house, are necessary complementary strategies.

Paving is the preferred option when contaminated soil is found in high-traffic areas. Contaminated soil should be disturbed as little as possible in preparing the surface, and precautions must again be used in managing any soil that must be removed.

While many paving materials are available, a high-quality concrete or asphalt cover is recommended, with appropriate allowance for thermal expansion and traffic loadings, so that cracks will not develop over time. Any areas of bare (contaminated) soil remaining at the edges of the paved surface should receive a grass or similar soft cover.

Soil removal and replacement

Soil removal and replacement is the most expensive and also the most hazardous soil abatement option. It should only be considered when soil contamination is extensive, behavioural factors are unfavourable (eg, a child with pica), and soft or hard ground cover is unlikely to be sustainable. In this situation, core samples should be taken from the affected area in a grid pattern to check that the expected decline in soil lead content with depth occurs (ie, that sublayers do not have equally or even higher lead content than the surface layer, as a result of historical events such as previous building or renovation on the site).

Typically, the soil profile shows a dramatic decline in lead content below 5 cm from the surface; however, removal of the top 15 cm (approximately) is recommended to provide a safety margin for activities that may disturb the surface such as gardening.

Soil removal generally involves a mix of both mechanical and manual methods. In either case, excavated soil should not be left on the property at the end of the working day (because of the risk of wind and water erosion leading to contamination both on-site and to neighbouring properties) but should be disposed of in an appropriate landfill. (Many jobs can, in fact, be completed in one day if properly managed and resourced.)

The soil that is removed should be disposed of at a hazardous waste facility and must not be used as top soil at another property.

Vehicles, containers and digging equipment must be washed down after use, and the waste water must be collected and filtered prior to disposal in a manner agreed by the territorial authority. Disposal to an on-site stormwater disposal soak-away may be acceptable.

At the end of each working day (and at the completion of soil removal), soil that has spilled from the excavation site onto adjacent grass or paved surfaces should be swept up and disposed of. Remaining soil particles contaminating grassed areas will largely be washed into the underlying soil by rainfall and will be rendered inaccessible (non-bioavailable) as a result of the grass cover. However, paved surfaces that have been contaminated with (leaded) soil, (such as patios, paths, concrete strips, driveways) may need to be vacuumed, hosed down, and vacuumed again. An industrial-strength vacuum cleaner fitted with a HEPA filter on the exhaust would be sufficient for relatively smooth surfaces and small areas. Alternatively, a suitable pavement cleaning machine (available from most local authorities) may need to be used, in which case the surfaces should be kept moist to minimise dust production.

After clean-up, replacement soil containing less than 210 µg/g of lead can then be installed, to a final grade of 5 cm above existing grades (to allow for settling and ensure that all drainage is away from the area). The replacement soil can then be covered with turf, bark chip, or other suitable cover.

Worker and occupant protection are both important during soil abatement. In particular, ensure that site access controls do not operate only during working hours and that children and pets are denied access at all times until the area is safe.

Water

If measurements of lead concentrations in the first flush drinking-water are compared with measurements after flushing, a reduction in lead levels indicates the reticulation system is the most significant contributor to lead dissolution. Remediation extends to point of use treatment, component replacement or other treatment options. If no significant reduction in lead concentration occurs on flushing, the lead is most likely entering the system via the collection or possibly the storage system.

Abatement options

Management of the supply

Some plumbing fittings have the potential to allow minute traces of metals to accumulate in water standing in the fittings for several hours. Although the health risk is small, a mugful of water should be flushed from drinking water taps each morning, before use, to remove any metals that may have dissolved from the plumbing fittings. Te Whatu Ora recommends this simple precaution for all households, including those on public and private water supplies.

Automatic flushing by use of a solenoid valve fitted at the end of each plumbing run can get over the latter; however, there is the initial cost of purchasing of solenoid valves and time clocks.

In-line dosing

To reduce softness of roof or shallow bore water, installation of an in-line filter containing limestone material can neutralise the acid dissolution effect. Waters less than pH 6.7 generally accentuate lead dissolution.

The limitation of this approach is that treatment is only successful in water temperatures above 5°C and where iron concentrations are less than 0.5 mg/l. Therefore, in cold winter climates this treatment may not be an option.

Point of use filters

These are effective on single cations only, that is where water supplies have two or more metals of health concern, two or more filters in series must be employed.

There are inherent problems with point of use filters, including maintenance, cartridge replacement, record keeping (in order to establish the replacement frequencies), bacterial build-up (generally controlled through regular maintenance of filters or other pre-treatment options).

Total removal of lead-containing components

This generally involves replacement of all lead componentry. The advantage is obvious; the solution is permanent and involves no ongoing costs.

The disadvantage is initial capital cost to replace materials, together with the associated labour costs.

Combination of options

The opportunity exists for combinations of options, such as the gradual replacement of lead-containing components, and use of in-line treatment and management approaches.

Schools generally will find it difficult to invest in significant treatment; however, the decision to follow a particular course of action may be influenced by the severity of the problem.

Protection during abatement

Most abatement jobs will generate or release lead-contaminated dust. Protection of workers and their families, residential occupants, household items, and the environment is therefore of critical importance to minimise the risk of short-term increases in dust lead hazards arising from the abatement activities themselves.

The following advice should be read with any Codes of Practice or other guidance issued by WorkSafe.

Protection of workers and their families

Lead may contaminate the hands, face and hair of the workers, or their clothing (work overalls) and footwear.

Workers should use disposable overalls if possible, but otherwise change out of work clothes before leaving the site. The work overalls should be placed in a laundry bag and laundered separately from other family clothing.

Hair should preferably be kept short, but otherwise restrained in a (disposable) hair net or cap.

Workers should wash hands and preferably shower before donning home clothes and departing the work site (otherwise shower as soon as getting home, and before cuddling or playing with young children).

Footwear should be covered with protective (disposable) booties or reserved for use at the work site (ie, change into home footwear just before leaving the site).

These precautions should be sufficient to protect the worker's car and home environment from contamination with take-home lead, as well as preventing direct transfer of lead from the hands, skin, hair, clothing or footwear of the worker to young children with whom the worker may come into contact.

Workers, are of course, themselves exposed to lead dust while carrying out abatement work and may suffer adverse health effects as a result. Exposure may be by both ingestion and inhalation, depending on particle size distribution and other factors. Depending on the nature of the work, a suitable respirator or mask (complying with AS/NZS 1716: 2012 Respiratory Protective Devices), gloves, overalls, goggles and boots may be required to protect the worker. Respiratory protection is generally required only for large-scale paint

removal jobs. (See *Paint removal* section, and consult WorkSafe if further advice is required.)

Occupant protection

For anything other than minor abatement jobs, and particularly if paint removal is involved, temporary relocation of preschool children, women who are or may be pregnant, and pets, is recommended.

As a minimum, children (and pets) should be kept well away from the work area.

Access restriction must apply at all times, not just during working hours, until the work has been completed and final clean-up has been done.

Re-occupation may then be permitted, or the decision may be made to maintain access restriction pending the results of clearance tests.

Environmental protection

While work should always be done in ways that minimise dust generation or release, dust can seldom be avoided entirely. It is important therefore that items such as furniture, furnishings, carpets, containers, toys, food, cosmetics, medicines, and so on be removed from the room and placed in lead-safe storage until it is safe to return. Items that cannot be removed (such as fittings, carpets and floors) should be covered with an appropriate sheeting material, taped down at the edges as necessary. Experience shows that clean-up is much more satisfactory if all items including carpets are removed.

Similarly, for exterior work, ground-sheets should be used beneath the work area. Windows, doors, ventilation holes and the like should also be sealed with adhesive tape. While a variety of sheeting materials may be used, disposable polythene sheeting is recommended. Non-disposable sheeting must be thoroughly washed between uses. It may become a source of contamination rather than a containment device if washing is not completely effective. Shaking soiled overalls, and thereby generating dust, should also be avoided.

Disposal of abatement wastes

Small amounts of solid wastes (debris, dusts) can be bagged and disposed of as ordinary household refuse. Similarly, small volumes of waste water (eg, used wash water) can be tipped down the sink. Cloths and mop heads should be disposable. They may also be bagged and treated as non-hazardous domestic waste.

Large amounts of debris, polythene sheeting, and other solid wastes should be appropriately contained (eg, placed in polythene bags) and disposed of as low-grade hazardous waste by co-disposal in a landfill designated for this purpose. The same applies to building components, carpets and the like that have been removed as part of the abatement process.

Lead-based paint containing wood debris should never be used as firewood because this will generate lead fumes, as well as leaded ash that may cause disposal difficulties.

Large volumes of contaminated water are generated by water blasting as a paint removal technique, and they should be treated before being disposed of in a manner approved by the territorial authority and/or the regional council. Acceptable treatment may comprise passage through an earth dam or filter and disposal to the sanitary sewer or to an on-site soak-away, providing no groundwater is likely to be affected. Disposal to a stormwater system discharging to natural water is unlikely to be acceptable.

Post-abatement clean-up

Although most leaded dust should have been retained on the polythene sheeting or other material used as floor/ground cover, it is essential that a thorough clean-up be done at the completion of the abatement work.

Once the cover material and abatement equipment has been cleaned and removed from the site, all surfaces that may potentially have received dust-fall should be cleaned. The recommended cleaning cycle is the same as that used for ongoing dust suppression (see next chapter) that is, a dry HEPA vacuum, followed by a common detergent wash, followed by a wet HEPA vacuum. If the abatement job has been large scale, and particularly if it has involved extensive paint removal, the cleaning cycle should be repeated twice.

Further rounds of cleaning may be indicated by the results of clearance tests (if any). In any event, cleaning cycles will almost certainly need to be repeated at regular intervals to manage (ongoing) dust build-up, unless all sources of lead in dust have been eliminated.

Clearance testing, ongoing monitoring and re-evaluation

In situations where the blood lead level of the index case at notification exceeds 1.2 $\mu\text{mol/l}$, environmental contamination is assessed as likely to be extensive, the case is judged to be especially vulnerable (eg, because of a pica habit), and/or large-scale abatement is being planned, the decision will generally be made to carry out pre-abatement environmental sampling.

In that case, it will generally be appropriate to carry out post-abatement or clearance environmental sampling as well, for comparison with the pre-abatement levels and recognised standards. Serial environmental testing may be carried out at intervals thereafter to monitor the effectiveness of corrective action or ongoing dust control measures, but should seldom be necessary. The cost of laboratory analysis, together with the lack of well-validated health-based standards for comparison, and the problem of sampling variability, limit the usefulness of environmental monitoring in practice.

Instead, greater reliance should be placed on serial blood lead measurements of the index case (and other exposed household members where appropriate). Blood lead is a biomarker that integrates exposure from all sources, and has a well-established relationship to health outcomes. It is also particularly sensitive to recent (past three to four weeks) rather than cumulative exposure, making it well suited for trend analysis. Failure of blood lead levels to fall as expected could indicate several situations: the transient increase in environmental contamination that may result from some abatement activities if adequate precautions are not taken, inadequate implementation of abatement interventions, incomplete identification of hazards (and pathways of exposure) in the risk assessment phase, or replacement of excreted lead by lead stored in bones as a result of high cumulative exposure.

Finally, many abatement techniques require periodic re-evaluation to ensure their continued integrity. Usually this can be achieved by visual inspection alone.

The table below summarise the recommended re-evaluation schedules:

Abatement method	Re-evaluation frequency	Type of re-evaluation required
Paint film stabilisation	Initial evaluation at six months. Annual inspection by the building owner. Independent inspection at years 5, 8 and 10.	Visual examination of painted surface. Adjacent dust sampling if doubtful.
Treatment of friction/ impact samples	Generally as for paint film stabilisation unless other methods used.	As above.
Surface coating	Initial evaluation at six months. Annual inspection by the building owner. Independent inspection at five-yearly intervals.	As above but also examine for extensive delamination. Check for building defects that could compromise surface coating.
Paint removal	None (if all paint removed).	Not applicable.
Enclosure	Initial evaluation at six months. Annual inspections by building owner. Independent inspection 10 yearly.	Visual examination of seals; dust sampling if in doubt. Check for building defects that could compromise enclosure.

Abatement method	Re-evaluation frequency	Type of re-evaluation required
Building component replacement	None.	Not applicable.
Soil cover (soft)	One month initially, then three months, thereafter annually.	Visual examination of extent of cover.
Soil paving or removal	20-yearly.	Visual examination.

Chapter 5:

Risk reduction – behaviour modification

Main points

- Abatement strategies should usually be complemented by behavioural strategies.
- Behavioural measures can be used to reduce exposure to lead hazards, and diet can affect the absorption of ingested lead.
- Behavioural strategies can be categorised into three groups:
 - house cleaning
 - personal hygiene
 - diet.
- Vacuum cleaning should be carried out using equipment capable of operating in both wet and dry conditions and be fitted with a HEPA filter, especially for dry vacuuming.
- Wetting of surfaces is a simple but effective dust suppression technique.
- Common detergent is effective in cleaning dust containing lead.
- Soft furnishings should be commercially cleaned where possible.
- Hygiene measures should be appropriate to the circumstances (ie, depending on blood lead levels, level of environmental lead contamination, case's exposure and behaviour, etc).
- Diet can have a significant effect on lead absorption. Advice on healthy eating should follow the *Eating and Activity Guidelines* (Ministry of Health 2020).⁴

Introduction

While abatement is directed towards elimination or control of lead hazards, behavioural measures can be used to reduce exposure to these hazards, and diet can affect the absorption of ingested lead. Environmental, behavioural and dietary strategies are complementary processes, the relative efficacy of which depends on the extent of lead contamination and the vulnerability of the receiving population. Environmental controls are most effective when contamination is extensive, or exposure is difficult to influence as a

⁴ A range of guidance documents are available on the Health New Zealand website:

<https://www.tewhātuora.govt.nz/our-health-system/preventative-healthwellness/nutrition/eating-and-activity-guidelines>.

result of pica or excessive hand-to-mouth behaviour. In most other situations, behavioural adjustment will be effective on its own, although obvious lead hazards should always be abated.

Environmental and behavioural strategies in reality merge into one another, and some interventions include elements of each. With the exception of some abatement interventions that are one-off procedures, all strategies require ongoing maintenance and reinforcement, at least until potentially exposed case(s) age out of the window of susceptibility (generally regarded as age six), or relocate to a lead-safe environment.

Behavioural strategies can be categorised into three groups:

- house cleaning (dust control)
- hygiene (personal care)
- diet (absorption control).

Hygiene and dietary advice also apply to firearms users (see Appendix 5).

House cleaning

House-cleaning routines are intended to suppress dust lead loading, the major exposure pathway for most non-pica children. These routines are similar to the clean-up process carried out at the end of abatement activities and use a combination of vacuuming and washing to collect and remove dust.

A meta-analysis of randomised controlled trials of low-cost lead dust controls (education about cleaning, provision of cleaning supplies or equipment, or professional cleaning) found that the reduction in blood lead level was greater for children who had a blood lead level of 0.72 $\mu\text{mol/l}$ or more. There was no significant reduction in average blood lead level for children in intervention groups compared with control groups (Haynes et al 2002).

Vacuuuming

Vacuuuming must be done with a cleaner with a sufficiently powerful motor to collect most particulate from most surfaces, including from within carpet pile and cloth (all of which may vary widely in texture).

The cleaner exhaust must be fitted with a HEPA filter. Otherwise, fine particles will simply circulate again, and (depending on building ventilation patterns) may subsequently settle in more accessible locations. (HEPA filtration is particularly important for dry vacuuming. Once dust has been wetted, there is less risk of resuspending fine particles.) It is

recommended that, in all buildings known to have lead paint used in the interior or exterior, a HEPA filter should be used to minimise the airborne redistribution of dust.

Ordinary domestic wet/dry machines, or the commercial carpet cleaning machines available for hire from some supermarkets and hardware stores may suffice for a wet vacuum, for which HEPA filtration is less important. Further information about the range of appropriate cleaners available, and their suitability for use in dry and wet modes, can be gained by contacting the manufacturers or their local agents directly.

The cleaning of moderately or heavily lead contaminated soft furnishings using HEPA vacuuming and steam cleaning may not remove sufficient lead-containing material and under some circumstances may make the lead more bioavailable. In many situations, replacement is the recommended option for soft furnishings.

Washing

Wetting of surfaces is an important dust suppression technique.

Water should be used on hard surfaces and may be suitable for many carpet and other fabrics, using a wet and dry vacuum cleaner.

Large, flat surfaces such as walls, ceilings and wood cork or linoleum floors, can be wet mopped. A moist cloth or wipe can be used on window sills, glazing bars, around door frames, furniture, fixtures and appliances.

When washing with water, a common detergent should be added.

If possible, mop heads and washcloths should be disposable. If not, they will need to be carefully laundered before re-use. Cleaning equipment (ie, the vacuum cleaner, mop handle and wash-bucket) must also be wet-wiped after each use (or repeatedly washed out in the case of the bucket) to avoid re-contaminating the environment with the next 'cleaning'. Care is required in disposing of used wash water and full vacuum dust bags to avoid clean (and cleaned) areas from becoming contaminated.

The cleaning cycle

The recommended cleaning process is an initial ('dry') HEPA vacuum (to remove visible traces of dust), followed by a detergent wash, followed by a second ('wet') HEPA vacuum to remove dust particles 'loosened' by the wash. If no HEPA filtered cleaner suitable for wet vacuuming is available, use an ordinary domestic wet/dry cleaner or a commercial

carpet cleaning machine for this vacuum. (A HEPA filtered cleaner is **essential** for the dry vacuum, however.)

If necessary, the cleaning cycle may be repeated twice on each cleaning occasion. The frequency of cleaning will depend on the 'dustiness' of the environment, effectiveness of abatement measures (if any), and serial blood lead (and, if done, lead dust) measurements. In most situations, a weekly single cycle routine will suffice.

Soft furnishings, such as rugs and curtains, act as dust traps and should be commercially cleaned at regular intervals (generally monthly to quarterly). Rugs, curtains and removable carpets can be cleaned off-site, which is preferable. Fitted carpet and soft furniture which are difficult to send for commercial cleaning may be cleaned by an initial HEPA vacuuming, followed by wet vacuuming where the material is unlikely to be damaged. Alternatively, steam cleaning should be considered for carpets. Fabrics that may be damaged by water (or steam), and cannot be removed for dry cleaning off-site, should be HEPA vacuumed frequently, say twice weekly. The use of aerosol foam fabric cleaners, following the manufacturer's instructions, may assist in fabric cleaning, but there is no evidence that they assist in the removal of dust lead. Other furniture, such as veneered or carved wood, can be HEPA vacuumed and wiped with a cloth moistened with a furniture polishing oil to assist in the collection of dust.

Dust suppression may also include sweeping and hosing down of exterior paved surfaces (patios, paths, concrete strips, driveways). If exterior dust is shown to be a major exposure pathway, a similar cleaning cycle to that used indoors can be instituted. Suitable hand-controlled pavement cleaning machines may be available from the local authority, or can be hired from commercial sources. These can produce dust emissions and surfaces should be moistened.

In designing an appropriate cleaning schedule, the household's current house-cleaning routine and access to resources (financial and human) must also be taken into account.

Hygiene

Hygiene measures are a collection of strategies designed to reduce exposure to paint, dust and soil through change in the behaviour of the exposed population (people and pets).

Not all the measures listed below will be appropriate for each situation.

Care of an affected child

The most successful strategies require parental supervision of the child and physical separation of the child from the hazardous environment. Environmental modification will be the primary protective activity. Parents should be reminded that lead has a sweet taste, and children may develop a craving for it.

If the child is under the care of a paediatrician, then they may be able to help with advice for parents and caregivers. A child with a resistant pica habit should always be referred for full paediatric assessment, irrespective of blood lead level.

- Fingernails should be kept short, because they can act as dust traps.
- Toys can be washed regularly, especially those likely to be chewed, sucked or cuddled.
- Washing the affected child's hands and face before meals or having a nap is useful (a wet wipe can be used).
- Children should not be fed on the floor, or while playing on the ground. Discourage children from picking up and eating food that has fallen onto the floor or ground.
- Encourage the affected child to play in safe areas – indoors on cleanable uncarpeted floors away from windows, outdoors on paved or grass-covered areas away from the house or other painted surfaces.
- Playing in bare soil (other than a tested sand pit) should be discouraged.

Household pets

Pets can act as dust traps, accumulating dust and soil particles on their fur. They can also track soil into the house on the under-surface of their paws.

If possible, limit access of pets (dogs and cats) to the living space, particularly principal play areas and eating areas.

- Do not allow pets to sleep on the affected person's bed.
- Discourage children from directly licking or kissing the pet.
- Wash pet dogs regularly.

Soil tracking

A walk-on mat can be provided at entrances to the house (which should be regularly HEPA vacuumed). This should be combined with encouragement to residents and visitors to remove footwear at the entrance, so reducing the tracking of soil into the house. Boots

and other footwear heavily covered with soil should be washed off using an outside tap or hose, well away from principal play areas.

Food

- Wash soil off root crops (eg, potatoes) before eating.
- Wash vegetables and fruit before eating (to remove leaded dust fall).
- Store food and eating/cooking utensils in sealed containers or closed cupboards that will protect them from dust fall.
- If visible traces of dust are present, the utensil should be washed before use.

Diet

Diet can have a significant influence on lead absorption, varying this from 50 to 60 percent down to 10 to 20 percent of the ingested dose for a young child. The *Eating and Activity Guidelines* (Ministry of Health 2020) describe a healthy diet that is likely to meet the complete nutrient and energy requirements of the population group and therefore promote optimal nutritional status.

Frequency of meals

Animal experiments and human volunteer studies have shown that lead is absorbed much better on an empty stomach. Frequent small meals, rather than fewer large meals, will significantly reduce the absorption of ingested lead. For young children with limited stomach capacity, small meals and snacks are needed, rather than three large meals.

Fat content

Fat increases lead absorption. A diet with moderate fat content is recommended; this can be achieved by adherence to the *Eating and Activity Guidelines (including the age-appropriate Food and Nutrition Guidelines series)* (Ministry of Health 2020).

Minerals and vitamins

Lead absorption is strongly influenced by nutritional status, in particular, iron and calcium deficiency.

Iron-rich foods include (lean) meat, chicken and seafood. Cooked or canned dried beans (eg, kidney beans, baked beans), chickpeas, lentils, split peas and tofu contain iron, but it is not absorbed as well as from animal foods. Iron absorption is assisted by vitamin C, so

servings of fruit and vegetables (eg, citrus fruits, kiwifruit, leafy green vegetables, broccoli, tomatoes, capsicums) should be promoted. Tea contains tannins, which lowers the amount of iron that the gut absorbs. It is recommended to drink tea between meals rather than at mealtimes. Tea should not be fed to infants because it inhibits iron absorption.

Absorption of ingested lead is inhibited by phosphate (which complexes it in the gut), and other heavy metals (in particular, calcium and zinc), which compete with it for transport from the gut.

A diet that follows the *Eating and Activity Guidelines (including the Food and Nutrition Guidelines series)* will contain sufficient minerals and vitamins; dietary supplements are not generally recommended. To ensure an adequate calcium intake, children should be encouraged to consume at least two servings of milk or milk products each day. A serving is equivalent to 1 glass of (reduced fat) milk $\frac{3}{4}$ cup yoghurt or 2 slices of cheese. If plant-based milk alternatives, such as soy, rice, almond or oat milk, are being used, ensure they are calcium-fortified.

If iron deficiency is suspected, this should be discussed with the case's general practitioner (or paediatrician or physician).

Breastfeeding

Breast milk is the ideal and preferred food for infants. Lead levels in breast milk are 1 to 10 percent of whole blood levels (reflecting equilibration with the plasma rather than the red cell compartment). Unless maternal blood lead is very high, therefore, breast milk should be safe. An expressed breast milk sample can be tested if there is concern, and the result can be related to the volume of breast milk being ingested by the infant, to estimate exposure from this source. The table below can be used as a guide:

Age of child (months)	Typical weight (kg)	Typical volume of breast milk ingested per day (ml)*
1	3.5	500
3	5.5	750
6	7.5	1000

* Derived from infant formula feeding guidelines.

Given the benefits of breastfeeding, the decision to breast feed or not, based on the concentration of lead in breast milk, should be decided on a case by case basis in discussion with the case's general practitioner.

Compliance monitoring and outcome evaluation

Behavioural protocols will have to be maintained until the child has grown out of the period of susceptibility, typically taken to be age six.

Given the cumulative exposure that may have already occurred (ie, the size of the bone pool that will act as an internal source), and the variable effectiveness of available environmental and behavioural strategies in limiting exposure to external sources, rapid decline of blood lead should not be expected. A slow but steady fall of as little as 0.05-0.10 $\mu\text{mol/l}$ per month should be accepted as satisfactory. Plateauing over several months or actual rebound in blood lead should lead to re-assessment of compliance with behavioural protocols, and review of effectiveness of abatement work. There might also be previously unidentified lead hazards and open exposure pathways.

Chapter 6:

Roles and responsibilities

Role of public health officers

Public health officers will respond to notifications of persons with raised blood lead levels. Officers should aim to facilitate households taking responsibility and ownership of the problem. Coordinating the case's care and follow-up may include:

- arranging for repeat blood lead testing of the index case, and other household residents (or other appropriate contacts, for example, from an early childhood care centre) as required
- in consultation with the general practitioner, arranging paediatric or physician referral of the index case (and other cases)
- communicating with general practitioners or paediatricians. For example, writing to the relevant GP when a case is notified from someone other than the patient's GP (such as the laboratory or hospital), or writing to a paediatrician if blood lead levels are over $0.96 \mu\text{mol/l}$. Telephone contact should be made with a paediatrician to arrange urgent assessment if the child's blood lead level is $\geq 2.17 \mu\text{mol/l}$. Examples of template letters are provided at Appendix 2.
- assessing nutritional status (especially iron) and diet of the index case (and other cases) in consultation with community dietitians
- educating the household about the health effects of acute and chronic lead exposure
- educating the household about how the risk of exposure to and absorption of lead can be reduced by behavioural strategies (house cleaning, hygiene and diet)
- assisting the household to participate in the development of a risk reduction plan
- advising the household on implementation of this plan, with particular regard to behavioural risk reduction strategies, and monitoring compliance with these strategies
- advising the household to obtain temporary lead-safe accommodation, if necessary
- liaising on the household's behalf with the property owner/landlord (if the occupier is not the owner) and with insurers, if necessary
- ongoing monitoring of the person's health, in particular through serial blood lead measurements, in partnership with the general practitioner or, less commonly, the paediatrician or physician

- communicating with the household at all stages of the investigation and follow-up, ensuring that their concerns are listened to and addressed, and all findings and options are fully discussed with them from the perspective of the case's and household's health
- ensuring that all necessary information is shared between the public health officer, the laboratory, the general practitioner, paediatrician or physician, other relevant organisations or individuals, and the household (while safeguarding the household's right to privacy and confidentiality)
- if necessary, issuing a certificate to the territorial authority regarding injurious or unfit condition of a dwellinghouse under section 42 of the Health Act 1956, as a last resort.
- when exercising the power of entry and inspection under section 128 of the Health Act, notifying (by notice in writing) the appropriate territorial authority if they believe that any building or site work does not comply with the Building Act 2004 (section 128A of the Health Act).

The specific skills of the health protection officer will be required to:

- carry out a risk assessment to identify contributory sources of lead (lead hazards) and (open) pathways of exposure to lead (including collection of environmental samples for laboratory analysis, and interpretation of laboratory results)
- design an appropriate abatement (source elimination) and management (exposure control) strategy in consultation with the household, the general practitioner, public health nurses, the territorial authority and other parties as appropriate
- advise the household on the implementation of the abatement strategy, including precautions to take
- ensure the implementation of key abatement processes
- evaluate the effectiveness of the risk reduction plan, including clearance (post-abatement) environmental testing if appropriate (and take corrective action as necessary)
- liaise with local authority officers and local WorkSafe officers, and other environmental agencies as required.

On rare occasions, it may be necessary for local authority officers to enforce the abatement plan through the exercise of legal powers through the Health Act 1956 or the Building Act 2004.

Role of WorkSafe

WorkSafe New Zealand is responsible for setting controls for the use of hazardous substances in the workplace. WorkSafe New Zealand administers workplace legislation, including controls of hazardous substances transferred from the HSNO Act. WorkSafe New Zealand has responsibility for explosives (including fireworks), manufacture, packing, labelling, wholesale, retail, use/reuse, remediation of contaminated land by workers, and investigation of workplace chemical injuries. This includes:

- controlled substances licensing
- test certification
- issuing approvals (or waivers) for people, sites or equipment, including, for example, burners, tanks, dispensers, compliance plans and maintaining approvals registers
- developing and approving codes of practice for workplace activities
- providing information on how to comply with hazardous substance legislation in the workplace
- dealing with workplace hazardous substance enquiries.

Notification to WorkSafe

Medical officers of health are required to notify WorkSafe New Zealand of work-related notifiable disease or hazardous substances injury (under section 199 of the Health and Safety and Work Act 2015). This requirement applies to cases of:

- a notification under section 74 of the Health Act 1956 of a notifiable disease that they reasonably believe arises from work; and
- a notification under section 143 of the Hazardous Substances and New Organisms Act 1996 (HSNO Act) of an injury caused by a hazardous substance that they reasonably believe arises from work.

To notify WorkSafe, please use the form: "*Notifications by medical officers of health - Notifications under section 199 of the Health and Safety at Work Act 2015*" (see Appendix 4). Please email the notification to: healthsafety.notification@worksafe.govt.nz.

Each individual notification should be sent to WorkSafe in a separate email.

The information from the notification is most useful if it includes the contact details of the patient's workplace and the patient's consent to pass that information to WorkSafe. WorkSafe can follow up with the business and, if necessary, can visit the business to ensure safe work practices are being maintained.

A person conducting a business or undertaking (PCBU) is also required to notify WorkSafe under section 56 of the Health and Safety at Work Act 2015 of lead poisoning that arises from work if it was a notifiable event (ie, a death, a notifiable illness or injury, or a notifiable incident).⁵ The medical officer of health should inform the case (and the PCBU if the case agrees) of this obligation.

Role of territorial authorities

In non-occupational settings, territorial authorities will normally be the regulatory agency with statutory authority to bring about a remedy. Territorial authority enforcement officers may collaborate with the other agencies, and the public health officer should provide the territorial authority with information and advice. Territorial authorities have duties and powers to prevent or control lead hazards under the following legislation.

Health Act 1956

The Health Act 1956 includes provision for territorial authorities to:

- improve, promote and protect public health
- cause steps to be taken to abate nuisances or to remove conditions likely to be injurious to health or offensive
- enforce regulations under the Act
- make bylaws for the protection of public health
- issue cleansing orders, repair notices or closing orders.

Section 29 of the Act defines health ‘nuisances’ and generally includes matters ‘likely to be injurious to health’. Particularly relevant are references to:

- accumulations or deposits
- situation or state of premises
- conduct of any trade, business, manufacture or other undertaking.

Enforcement in relation to nuisances is determined by the District Court if a nuisance is not abated voluntarily, except where immediate action is necessary. Works undertaken by a territorial authority to abate a nuisance may result in costs being recovered from the owner or occupier. It should be noted, however, that any person can lay information regarding a

⁵ An explanation of notifiable events is available at: <https://www.worksafe.govt.nz/notifications/notifiable-event/what-is-a-notifiable-event/#if-doc-39637>.

nuisance. A nuisance has to exist before any action can be taken and, accordingly, is not an effective means of preventive action.

Under section 41 of the Act, the territorial authority may serve a cleansing order on the owner or occupier, specifying the work to be carried out and the time in which to complete it. They may also issue a repair notice on the owner (or their agent) of a dwelling house under section 42. A closing order made under sections 42 or 44 can be issued as a last resort to protect the occupants, but such action will not, of course, resolve any external release of lead.

Building Act 2004

The Building Act 2004 includes provision for territorial authorities to:

- require work to be done to prevent buildings from remaining or becoming dangerous or insanitary
- take measures to avert danger or rectify insanitary conditions
- issue project information memoranda revealing (inter alia) known hazardous contaminants.

A building consent will be required in most cases where demolition or structural alteration works are to occur. The ability to impose conditions on building consents appears to be limited to inspections or to enter premises (section 222). Nevertheless, territorial authorities could, at their discretion, include a 'Hazardous Building Material Warning' on relevant consent documents.

Project Information Memoranda (PIM) issued by territorial authorities must include information identifying special features of the land relating to the likely presence of hazardous contaminants where it is:

- likely to be relevant to the design and construction or alteration
- known to the territorial authority
- not apparent from the operative district plan.

Sections 121 to 130 deal with dangerous, affected, and insanitary buildings. It is possible that the presence of lead could cause a building being considered 'dangerous' or 'insanitary' for the purpose of the Act. Insanitary buildings include those of such construction as to be likely to be injurious to health. In determining whether or not a building is insanitary, consideration must be given to:

- size of the building
- complexity of the building

- location of the building in relation to other buildings, public places, and natural hazards
- intended use of the building, including any special traditional and cultural aspects of the intended use
- expected useful life of the building and any prolongation of that life
- reasonable practicality of any work concerned
- in the case of an existing building, any special historical or cultural value of that building
- any matter that the territorial authority considers to be relevant
- provisions of the building code.

Enforcement action is by way of formal notice requiring a remedy. An application for a court order authorising the territorial authority to do required work at the owner's expense may be made on default.

Local Government Official Information and Meetings Act 1987

Section 44A of the Local Government Official Information and Meetings Act 1987 allows for anyone to apply to the territorial authority for a land information memorandum (LIM). Matters that must be included in the LIM are information concerning the 'likely presence of hazardous contaminants' that is known by the territorial authority but is not apparent in the district plan.

Resource Management Act 1991

The Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES) provide a nationwide set of planning controls, a national set of soil contaminant standards and mandated investigation and reporting requirements. The NES is implemented by each territorial and unitary authority in accordance with their functions under the Resource Management Act relating to contaminated land, specifically section 31(b)(iia) 'the prevention or mitigation of any adverse effects of the development, subdivision, or use of contaminated land'.

Section 15 prohibits the discharge of contaminants into the environment except where some form of authority or consent exists. Section 17 requires every person to avoid, remedy or mitigate adverse effects on the environment.

Enforcement orders (by the Environment Court) or abatement notices (by an enforcement officer) may be issued requiring a person to cease, or prohibiting a person from

commencing, anything that is or likely to be noxious, dangerous, offensive, or objectionable to such an extent it is likely to have adverse effect on the environment.

Similar action may require a person to do certain things to avoid, remedy or mitigate adverse environmental effects.

The Resource Management Act 1991 also includes provision for territorial authorities to make plans and rules that deal with hazardous substances. The health protection officer should be aware of the appropriate provisions of plans and when the NES may apply, since advice given in the absence of such knowledge could create difficulties.

Role of property owners

Property owners, and their agents and/or managers, have the primary responsibility for correcting lead hazards arising from their property. Responsibilities include:

- meeting statutory obligations, such as under the Health Act 1956 and Building Act 2004
- providing properties that are lead safe
- assessing and managing all lead hazards arising from the property including hazards that have been caused by past actions such as lead-based paint removal
- administering and financing abatement work, including necessary repairs to the property
- selecting and agreeing to the abatement work with input from the public health officer and council as relevant
- engaging contractors for abatement work who are competent and appropriately trained
- informing contractors of the lead hazards
- monitoring the performance of contractors for compliance with work specifications
- revising routine property maintenance work practices to prevent lead hazards from being generated
- monitoring the condition of the property and abatement work to ensure that lead hazards do not recur
- obtaining necessary building consents and all other consents including those for the disposal of lead wastes and waste-water
- providing information to the occupier on lead hazards that the property may present and the steps that the occupier should take to minimise risks to the household
- informing purchasers of known or suspected lead hazards.

Landlords are thus required to protect occupants and others from (among other things) lead contamination arising from paintwork in the tenant's property or its fixtures and fittings.

The Residential Tenancies Act 1986 requires the landlord to provide and maintain the premises in a reasonable state of repair, with regard to the age and character of the premises (section 45(1)(b)). Landlords are also required to comply with all statutory building, health and safety requirements applying to the premises (section 45(1)(c)). Failure by a landlord to comply with these obligations is an 'unlawful act' under Residential Tenancies Act (section 45(1)A). The Act has a process by which a complainant can lodge a complainant with the Tenancy Tribunal.

Role of property occupiers

The responsibilities of owner-occupiers are as outlined above. If occupiers are tenants, they are responsible for reporting to the landlord on any potential lead hazard developing, cooperating with the landlord in facilitating abatement work, and monitoring the condition of abatement work.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2020. *Toxicological profile for Lead*. Atlanta: US Department of Health and Human Services, Public Health Service. URL: <https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf> (accessed 6 September 2023).

Armstrong R, Anderson L, Synnot A, et al. 2014. *Evaluation of evidence related to exposure to lead*. Canberra: National Health and Medical Research Council. URL: <https://www.nhmrc.gov.au/sites/default/files/2019-03/evaluation-evidence-exposure-lead.pdf> (accessed 6 September 2023).

Bellinger DC, Needleman HL. 2003. Intellectual impairment and blood lead levels. *N Engl J Med* 349: 500–2.

Binns H, Campbell C, Brown M. 2007. Interpreting and managing blood lead levels of less than 10 µg/dL in children and reducing childhood exposure to lead: Recommendations of the Centers for Disease Control and Prevention Advisory Committee on Childhood Lead Poisoning Prevention. *Pediatrics* 120: 1285-1298. DOI:10.1542/peds.2005-1770 (accessed 12 June 2017).

Canfield RL, Henderson CRJ, Cory-Slechta DA, et al. 2003. Intellectual impairment in children with blood lead concentrations below 10 µg per decilitre. *N Engl J Med* 348: 1517–26.

CDC Advisory Committee on Childhood Lead Poisoning Prevention. 2012. *Low level lead exposure harms children: a renewed call for primary prevention*. Atlanta: US Department of Health and Human Services, CDC. URL: www.cdc.gov/nceh/lead/acclpp/final_document_030712.pdf (accessed 6 September 2023)

Chen A, Dietrich KN, Ware JH, et al. 2005. IQ and blood lead from two to seven years of age: are the effects in older children the residual of high blood lead concentrations in two-year-olds? *Environ Health Perspect* 113: 597–601.

Crump KS, Van Landingham C, Bowers TS, et al. 2013. A statistical reevaluation of the data used in the Lanphear et al. (2005) pooled-analysis that related low levels of blood lead to intellectual deficits in children. *Critical Reviews in Toxicology* 43:785-799.

Evens A, Hryhorczuk D, Lanphear B, et al. 2015. The impact of low-level lead toxicity on school performance among children in the Chicago Public Schools: a population-based retrospective cohort study. *Environmental Health* 14:21. DOI 10.1186/s12940-015-0008-9 (accessed 20 July 2015).

FAO/WHO. 2011. *Evaluation of Certain Food Additives and Contaminants*. Seventy-third report of the Joint FAO/WHO Expert Committee on Food Additives. Geneva: World Health Organization (Technical Report Series 960). URL:

[https://apps.who.int/iris/bitstream/handle/10665/44515/WHO TRS 960 eng.pdf?sequence=1&isAllowed=y](https://apps.who.int/iris/bitstream/handle/10665/44515/WHO_TRS_960_eng.pdf?sequence=1&isAllowed=y) (accessed 6 September 2023).

Gray S, Read D, Nesdale A. 2009. Exposure to lead-based paint at an Early Childhood Centre. *New Zealand Public Health Surveillance Report* 7(4): 5. URL:

https://surv.esr.cri.nz/PDF_surveillance/NZPHSR/2009/NZPHSR2009Dec.pdf (accessed 6 September 2023).

Haynes E, Lanphear BP, Tohn E, et al. 2002. The effect of interior lead hazard controls on children's blood lead concentrations: a systematic evaluation. *Environmental Health Perspectives* 110: 103–7.

IARC. 2007. *Inorganic and Organic Lead Compounds*. Lyon: World Health Organization, IARC. Volume 87, p.378.

Lanphear BP, Hornung R, Khoury J, et al. 2005. Low-level lead exposure and children's intellectual function: an international pooled analysis. *Environ Health Perspect* 113: 894–9.

Lanphear BP, Succop P, Roda S, et al. 2003. The effect of soil abatement on blood lead levels in children living near a former smelting and milling operation. *Pub Health Rep* 118: 83–91.

Lanphear B, Weitzman M, Tanner M, et al. 1994. *Report to the National Centre for Lead-Safe Housing and the US Department of Housing and Urban Development*. Rochester: University of Rochester.

Ministry for the Environment. 2003. *Contaminated Land Management Guidelines No. 2: Hierarchy and application in New Zealand of environmental guideline values*. Wellington: Ministry for the Environment.

Ministry for the Environment. 2011. *Contaminated Land Management Guidelines No. 5: Site investigation and analysis of soils*. Wellington: Ministry for the Environment. URL: <https://environment.govt.nz/publications/contaminated-land-management-guidelines-no-5-site-investigation-and-analysis-of-soils/> (accessed 6 September 2023).

Ministry of Health. 1996. *Lead in School Drinking-water Supplies*. Wellington: Ministry of Health.

Ministry of Health and Ministry of Business, Innovation and Employment. 2013. *Guidelines for the Management of Lead-based Paint*. Wellington: Ministry of Health. URL: <https://www.health.govt.nz/publication/guidelines-management-lead-based-paint>

Ministry of Health. 2020. *Eating and Activity Guidelines for New Zealand Adults: Updated 2020*. Wellington: Ministry of Health. URL:

<https://www.tewhatauora.govt.nz/assets/For-the-health-sector/Health-sector-guidance/Active-Families/eating-activity-guidelines-new-zealand-adults-updated-2020-oct22.pdf>

Narsey H, Stevenson C. 1997. *Survey of Benzene, Aromatics, 1,3-Butadiene and Lead in Air*. A report for the Ministry of Health. Institute of Environmental Science and Research Ltd. Unpublished report, 41 pp.

National Health and Medical Research Council. 2015. *NHMRC Information Paper: Evidence on the Effects of Lead on Human Health*. Canberra: National Health and Medical Research Council. URL:

<http://www.nhmrc.gov.au/sites/default/files/documents/reports/lead-human-health-info-paper-eh58a.pdf> (accessed 6 September 2023).

National Toxicology Program. 2012. *NTP Monograph on Health Effects of Low-Level Lead*. Research Triangle Park: US Department of Health and Human Services, Office of Health Assessment and Translation. URL:

http://ntp.niehs.nih.gov/ntp/ohat/lead/final/monographhealtheffects/lowlevellead_newisn_508.pdf (accessed 6 September 2023).

Nawrot TS, Staessen KA. 2006. Low-level environmental exposure to lead unmasked as silent killer. *Circulation* 114: 1347–9.

Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011. URL:

<http://www.legislation.govt.nz/regulation/public/2011/0361/latest/whole.html> (accessed 6 September 2023).

Reckelhoff-Dangel C, Petersen D. 2007. *Risk Communication in Action: The risk communication workbook*. Cincinnati: Office of Research and Development, US Environmental Protection Agency. URL: <http://nepis.epa.gov/Adobe/PDF/60000I2U.pdf> (accessed 6 September 2023).

Reuben A, Caspi A, Belsky DW, et al. 2017. Association of childhood blood lead levels with cognitive function and socioeconomic status at age 38 years and with IQ change and socioeconomic mobility between childhood and adulthood. *Journal of the American Medical Association* 317:1244-1251 DOI:10.1001/jama.2017.1712 (accessed 6 September 2023).

Taylor CM, Kordas K, Golding J, et al. 2017. Effects of low-level lead prenatal lead exposure on child IQ at 4 and 8 years in a UK birth cohort. *NeuroToxicology* 62:162-169 DOI:10.1016/j.neuro.2017.07.003 (accessed 6 September 2023).

Tong S, Baghurst PA, Sawyer MG, et al. 1998. Declining blood lead levels and changes in cognitive function during childhood: the Port Pirie Cohort Study. *JAMA* 280: 1915–9.

USEPA. 2013. *Integrated Science Assessment for Lead (Final Report)*. EPA/600/R-10/075F. Washington, DC: US Environmental Protection Agency.

USEPA. 2019. Review of the dust-lead hazard standards and the definition of lead-based paint. *Federal Register* 84(131): 32632-32648. URL:

<https://www.govinfo.gov/content/pkg/FR-2019-07-09/pdf/2019-14024.pdf> (accessed 6 September 2023)

USEPA. 2020. Review of dust-lead post-abatement clearance levels. Proposed rule. *Federal Register* 85(122): 37810-37819. URL:

<https://www.govinfo.gov/content/pkg/FR-2020-06-24/pdf/2020-13582.pdf> (accessed 6 September 2023)

US Department of Housing and Urban Development. 2012. *Guidelines for the evaluation and control of lead-based paint hazards in housing*. Washington DC: Office of Healthy Homes and Lead Hazard Control, US Department of Housing and Urban Development

URL: https://www.hud.gov/sites/documents/SECOND_EDITION_2012.PDF (accessed 6 September 2023)

Weitzman M, Aschengrau A, Bellinger D, et al. 1993. Lead-contaminated soil abatement and urban children's blood lead levels. *JAMA* 269(13): 1647–53.

Yeoh B, Woolfenden S, Lanphear B, et al. 2014. Household interventions for preventing domestic lead exposure in children. *Cochrane Database of Systematic Reviews* Issue 12. DOI:10.1002/14651858.CD006047.pub4 (accessed 6 September 2023).

Appendix 1: Lead sampling and analysis

Main points

- Results of blood sampling should be interpreted carefully and attention paid to whether the sample was capillary or venous blood, and in which units the results are reported.
- A simple qualitative test for the presence of lead-based paint will generally suffice.
- Wipe methods of dust sampling are recommended for measuring dust lead loading.
- Dust sampling should be considered if the index case's blood lead level is over 1.2 $\mu\text{mol/l}$.

Blood sampling

The level of lead in blood is a measure of the amount of lead recently absorbed and therefore an indicator of recent exposure (ATSDR 2020).

Collection and analysis

When considering the results of the analysis of blood specimens, public health staff need to check whether the specimen was whole blood or capillary blood. This information should be included with the method of analysis on the laboratory report.

Capillary blood, from finger pricks, is appropriate for screening but if levels are elevated or action is being taken, whole blood samples should be analysed. Similarly finger pricks are appropriate for monitoring. Blood tests should be coordinated so all tests on the specimen can be done at once to minimise the need for further specimens to be taken.

Sample collection, storage, transport, and analysis must be undertaken correctly to ensure the reliability of the results. For example, care must be taken to avoid contaminating the sample at collection, and to avoid delays in dispatch to the laboratory.

It is recommended that only laboratories that have International Accreditation New Zealand (IANZ) registration for blood lead analyses be used. Laboratories conducting tests must be able to demonstrate adequate performance in a recognised quality assurance programme for blood lead assays.

Blood lead level unit conversions

To convert from micrograms per decilitre ($\mu\text{g/dl}$) to micromoles per litre ($\mu\text{mol/l}$), divide by 20.71.

To convert from micromole per litre ($\mu\text{mol/l}$) to micrograms per decilitre ($\mu\text{g/dl}$), multiply by 20.71.

1.0 $\mu\text{g/dl}$ = 0.04829 $\mu\text{mol/l}$	1.0 $\mu\text{mol/l}$ = 20.71 $\mu\text{g/dl}$
5 $\mu\text{g/dl}$	0.241 $\mu\text{mol/l}$
10 $\mu\text{g/dl}$	0.483 $\mu\text{mol/l}$
15 $\mu\text{g/dl}$	0.724 $\mu\text{mol/l}$
20 $\mu\text{g/dl}$	0.966 $\mu\text{mol/l}$
25 $\mu\text{g/dl}$	1.207 $\mu\text{mol/l}$
30 $\mu\text{g/dl}$	1.449 $\mu\text{mol/l}$
35 $\mu\text{g/dl}$	1.690 $\mu\text{mol/l}$
40 $\mu\text{g/dl}$	1.931 $\mu\text{mol/l}$
45 $\mu\text{g/dl}$	2.173 $\mu\text{mol/l}$
50 $\mu\text{g/dl}$	2.414 $\mu\text{mol/l}$
55 $\mu\text{g/dl}$	2.656 $\mu\text{mol/l}$
60 $\mu\text{g/dl}$	2.897 $\mu\text{mol/l}$
65 $\mu\text{g/dl}$	3.139 $\mu\text{mol/l}$
70 $\mu\text{g/dl}$	3.380 $\mu\text{mol/l}$

Conversions from the graded response protocol in Chapter 3

≥ 70 $\mu\text{g/dl}$	≥ 3.4 $\mu\text{mol/l}$.
≥ 45 $\mu\text{g/dl}$	≥ 2.17 $\mu\text{mol/l}$
20 – 44 $\mu\text{g/dl}$	0.96 – 2.16 $\mu\text{mol/l}$
15 – 19 $\mu\text{g/dl}$	0.72 – 0.95 $\mu\text{mol/l}$
14 – 10 $\mu\text{g/dl}$	0.48 – 0.71 $\mu\text{mol/l}$
5 $\mu\text{g/dl}$ – 9.7 $\mu\text{g/dl}$	0.24 – 0.47 $\mu\text{mol/l}$
< 5 $\mu\text{g/dl}$	< 0.24 $\mu\text{mol/l}$

Testing for lead-based paint

1. Testing of paint for the presence of lead (in excess of the standard) may not be necessary if the age of the paintwork can be established:
 - Pre-1945 paintwork may be assumed to be lead-based.
 - Paintwork dated between 1945 and 1965 is likely to be lead-based, but testing may be preferred to confirm this.
 - Testing is necessary for paintwork thought to date between 1965 and 1980, or if the age of the component is uncertain (that is, if paintwork cannot be accurately dated from the building and renovation history).
 - Post-1980s paintwork may be safely assumed to be below 0.25 percent lead, unless there is suspicion that old stock or industrial specification paint has been applied. (Exceptions may be lead chromate paints, which may occur to the late 1980s, and calcium plumbate paints on roofs to the 1990s.)

Note that determining the age of paintwork may be difficult if a full and accurate building and renovation history is not available.

2. Where testing is necessary, a qualitative field test ('spot test') is usually adequate. The sodium sulphide test has been extensively evaluated and is usually available at major paint retailers or home improvement stores. Each paint layer must be tested, as the lead paint may be covered by layers of non-leaded paint. Non-destructive testing by X-ray fluorescence (XRF) can also be used to determine the presence of lead.
3. Sodium sulphide test:
 - Clean the surface to be tested.
 - Rub freshly prepared 5 percent sodium sulphide solution onto the surface (an area of several cm² is sufficient) using a clean cotton bud.
 - If less than 1 percent lead is present in the surface layer of paint, the exposed surface will turn black.
 - The surface layer can then be sanded off, and the test repeated on each newly exposed layer in turn, until the underlying surface is reached.
 - The test may also be applied to paint chips or flakes, but is less well validated in this context.

The test is qualitative only, with a limit of detection of about 1 percent (10,000 µg/g) (which is adequate). The relatively high false negative rate makes it important to check the test against the standard whenever a new location is visited. There is,

however, a significant false negative rate (up to 15 percent when testing is done on dark colours), and occasional false positives.

4. Laboratory paint chip analysis can be done when a field test is negative (or positive or unclear) contrary to expectation (based on other evidence).

Cut a small paint chip (about 5 g) from the surface to be tested with a sharp knife, making sure all paint layers are represented. Place in a lead-free plastic or glass container such as a blood collection tube, and dispatch to the laboratory. The result can be reported as a lead concentration ($\mu\text{g/g}$), or loading ($\mu\text{g/cm}^2$), if the area of paint excised is measured.

5. Take care when collecting destructive paint samples (for field or laboratory testing) to avoid contaminating the adjacent area (or collect other samples – ie, dust or soil – first). Any destructive testing should be discussed with the owner, and if possible a site selected that is less visible (but still representative of the suspected lead-based paint hazard).
6. Where most or all lead-based paint has been worn away or artificially removed, the existence of a lead-based paint hazard at the site may only be indicated by indirect evidence – ie, demonstration of lead contamination of dust or soil adjacent to the location of the hazard. Such ‘inactive’ sources should still be identified and abated if necessary.

Dust sampling

When to sample

Dust lead loading may be measured for risk assessment or clearance purposes. It should be considered when (see Graded Response Protocol Summary):

- the index case has a blood lead level over $1.2 \mu\text{mol/l}$
- sources and pathways of exposure are not obvious from visual observation.

In other situations, dust control measures can be instituted (if necessary) without ‘before’ or ‘after’ dust testing.

Getting useful information from dust testing is not a straightforward process. Problems may be experienced with:

- difference in surface texture and condition
- measuring the area of the collecting surface
- timing collection in relation to time of last cleaning of the collecting surface

- consistently collecting all the dust deposited on the collecting surface
- avoiding sample contamination
- estimating case's exposure to dust at a particular site
- estimating the fraction of lead in dust at each site that is bioavailable.

Where to sample

Selection of sampling sites involves consideration of:

- case behaviour (location of principal play areas, time/activity relationships)
- lead-based paint hazards (nature and location) and (rarely) other lead hazards
- dust dynamics (dust deposition, dust removal by house cleaning routines).

Microenvironments in which the case spends significant time, that are located close to a lead hazard, and that have visible dust accumulations, are the sites to sample (if available).

A typical sampling plan might include:

- window sill in case's bedroom
- floor in case's bedroom
- window sill (if any) and floor principal play area (lounge, playroom)
- kitchen floor
- floor adjacent to any major area of damaged or deteriorated lead-based paint.

Window sills are a particularly important sampling site, as dust is likely to be generated from paintwork abrasion wherever the window is opened or closed, and the window area is often an attractive place for children to play. Window sills are often favoured by children for biting or chewing, as well.

A number of samples should always be taken, as considered together they will provide a more accurate picture of the exposure profile than any single sample, which could be spuriously high or low.

How to sample

The basic method for collecting surface dust samples is the wipe method. Wipe methods are more readily standardised and can provide more consistent and reproducible results than vacuum methods (Lanphear et al 1994), especially if results are expressed in terms of lead loading rather than lead concentration. The wipe method is therefore

recommended for all dust sampling, irrespective of the texture of the collecting surface. Vacuum methods may be used in certain specialised situations but advice from the laboratory should be sought before this is undertaken.

The sampling and analytical process must be standardised so that consistent results are obtained, whether before/after comparison or comparison with a standard (exposure limit) is to be made.

Standardised wipe method

1. A wipe material is required that:
 - is easily and completely digested to extract the lead
 - has low background lead content
 - is easy to use in the field
 - remains moist during the wipe sampling process.

A plain moist baby wipe (free of additional ingredients) is recommended.

2. To avoid contamination, collect dust samples before invasive paint sampling.
3. Time sample collection consistently in relation to time since last cleaning of the collecting surface. Sampling just before the next cleaning is due is recommended. It is pointless sampling just after a cleaning has been done.

Before sampling, wash hands thoroughly (or wear disposable surgical gloves – a fresh pair for each sample) and place an uncontaminated wipe into an uncontaminated plastic container. Seal and label this as the blank.

4. Accurately measure the area to be wiped. A disposable template may be used, or one created on site using masking tape. For a typical floor, an area of 40 cm by 40 cm is recommended. For a window sill, generally the whole sill can be wiped and measured.
5. Do not overload the wipe such that dust is falling off (such dust will adhere to the sample container so reducing lead recovery) – wipe a smaller area if necessary. (Alternately, use a second wipe for the same area – but this will increase analysis cost.)
6. Collect all visible dust from the measured surface. Try to use a consistent and steady wiping technique, using the palm with the fingers held together. Do not use the

fingertips to hold down the wipe, because there will be incomplete contact and dust will be missed. Ensure that the whole (measured) surface is covered.

7. Fold the wipe inwards to reduce the risk of sample loss. Place in a rigid plastic container (one for each site) and label, including the area wiped. Samples and blank may then be dispatched to the laboratory for analysis. Results will be reported as micrograms of lead per surface area wiped ($\mu\text{g}/\text{m}^2$) – ie, as dust lead loading.

Soil sampling

These sampling guidance notes are intended to assist public health officers where soil sampling is required as part of the case management of lead exposed persons. Sampling may be required to confirm risk identification (exposure pathways) and inform subsequent risk reduction strategies. These guidance notes are not suitable for assessing a site's contamination status for other purposes.

Sampling and analysis planning

Sampling soil for the presence of lead can assist the development of appropriate risk reduction strategies. Before collecting soil samples, some basic soil sampling and analysis planning should be carried out. This planning will assist officers to take meaningful and relevant samples. The planning should consider:

- the purpose of the soil sampling (ie, what additional information would the samples provide to assist with case management strategies)
- information about the site that may indicate the presence/absence and distribution of any lead contamination. This will include the location and history of potential soil contamination (eg, areas of lead paint, hobbies or repairs involving lead) or remediation activities
- the sampling collection technique and strategy to be used (eg, composite or individual samples)
- the location, depth, and number of samples that should be taken
- the order of sample collection (where practical, sampling should start at the part of the site suspected to be least contaminated to minimise the possibility of cross-contamination).
- any specific testing laboratory requirements regarding the collection and transport of samples.

Hazardous activities and industries list (HAIL) sites

If the site's current or historic land use means it has been identified by the local territorial or unitary authority as a known or suspected Hazardous Activities and Industries List (HAIL) site then the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES) may apply when taking soil samples to assess for contamination⁶. Territorial authorities are responsible for implementing the NES. Any site investigation (including taking, analysing or assessing samples) to meet the requirements of the NES is not within the scope of public health officers' work, although the results of such an investigation may inform the case management strategies.

If a public health officer's investigation of a lead-exposed case involves a HAIL site then the officer should liaise with the territorial authority. If no site investigation has been carried out and is not likely to be in the near future, (or lead contamination has not previously been investigated), then the public health officer should arrange for limited sampling to be carried out to meet their purposes ie, to assist in identifying the significant lead exposure pathways and priority areas for risk reduction strategies to reduce the case's lead exposure.

When to sample

Soil lead may be measured for risk assessment or evaluation (clearance) purposes. Sampling for evaluation purposes should be considered when:

- the index case has a blood lead level over trigger levels in the Graded Response Protocol Summary
- the index (or other resident) case has a confirmed pica habit (ie, eating of non-food items including soil)
- sources and pathways of exposure are not obvious from visual observation (for example, testing is not usually necessary if soil contains visible confirmed lead-based paint flakes or chips).

In other situations, soil abatement and behavioural exposure control measures can be instituted (if necessary) without 'before' or 'after' testing.

⁶ The Ministry for the Environment *User's Guide: National Environmental Standard for Assessing Contaminants in Soil to Protect Human Health* state: The land-use history is the trigger for determining whether the land is covered by the NES. If no preliminary site investigation has been undertaken and there is no indication of a previous HAIL activity (or the potential for it) in the council records then the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations don't apply.

Where there is visible contamination with known lead-based paint, this can be taken as evidence of soil contamination, reducing the need for testing and risk reduction strategies should be implemented.

Where to sample

The decision of where to sample will be specific to the case and site being investigated and should be based on information obtained during the initial case investigation process. The following locations should be considered when determining where to sample:

- principal outdoor play area(s)
- sand pit (if any)
- vegetable garden (if any)
- areas of soil readily tracked into the house
- bare soil areas within one metre of a lead painted surface (the dripline/foundation area), if the condition of paintwork is poor or there is a history of paint removal
- areas where debris from current or past renovation has been dumped or swept
- dust from paths, patios or concrete strips adjacent to the house and other buildings on site (especially if located adjacent to past or present lead-based paint hazards)
- areas where ashes from fires burning lead-based painted wood were emptied onto soil
- areas frequented by pets
- places where other lead-related activities may have occurred, (eg, boat or radiator repairing, fruit tree spraying prior to 1980, welding or preparing shot)
- areas where pica activity is known, or suspected, to be occurring and there is no obvious contamination.

Sampling strategy

Focusing on specific locations within the property (as opposed to undertaking sampling across the whole section) is referred to as judgemental (or targeted) sampling. Prior knowledge of contamination activities, evidence of contamination (eg, paint flakes) and the use of professional judgement are all used to select sample locations. Judgemental sampling is specifically useful for confirming the presence or level of a contaminant at a specific location or to provide screening information that can inform further investigation.

The use of judgemental sampling will often be an appropriate strategy for case-management. In this situation the focus is on exposure pathways affecting the lead-exposed case, as opposed to identifying the presence of lead hazards *per se*

However, as judgemental sampling is inherently biased, it is not appropriate where a statistically sound sampling regime, or information on the distribution of the contaminant over the whole site, is required – in these circumstances a more extensive, statistically sound, sampling regime is more appropriate. The soil-sampling strategy should be consistent with the purpose of the investigation. There are two other types of sampling patterns commonly used in contaminated land investigations: systematic and stratified. Detailed information on selecting sampling patterns can be found in the Ministry for the Environment's *Contaminated Land Management Guidelines No. 5: Site investigation and analysis of soils*.

Composite samples

Composite sampling occurs when individual samples from different spots are collected and mixed into one composite sample. This sample can then be analysed, and represents the average of the constituent sub-samples.

The benefit of composite sampling is its cost effectiveness as the number of samples that need to be analysed is reduced. However, this sampling method has some disadvantages as there is a loss of sensitivity in identifying areas with high lead levels. For example, a high lead concentration in one area may be masked by the sample being diluted by other areas where the level of soil lead is significantly lower.

Composite samples should be made up of the same number and weight of sub-samples. Ideally no more than four sub-samples should be used to make up the composite.

Sub-samples are usually taken from adjacent locations and from similar depths (ie, from the same soil/fill horizon).

Compositing is not suitable for soils that are not easily mixed (eg. clay) or for soils with different moisture contents.

The *Contaminated Land Management Guidelines No. 5* recommends compositing be undertaken at the laboratory and individual samples retained in case testing of individual sub-samples is required.

The number of samples that should be collected from each location is determined by the intended use of the data, the level of confidence required for the investigation, the area of the site and any site-specific constraints/limitations (including budgetary considerations). The sample planning process should identify the number of samples to be collected.

Appendix B (<https://environment.govt.nz/publications/contaminated-land-management-guidelines-no-5-site-investigation-and-analysis-of-soils/>) of the *Contaminated Land Management Guidelines No. 5* contains guidance on how to calculate

the minimum number of sample points required for statistically sound investigations and analyses.

For sampling around the perimeter of a building it is possible to make up a composite sample for each side of the building. The number of sub-samples should relate to the length of the side, ensuring the likely contamination level is similar along the areas where exposure is possibly occurring.

Remember that when comparing composite results against guideline values, the guideline value must be adjusted by dividing the value by the number of sub-samples in the composite:

$$\text{Adjusted guideline value} = \frac{\text{Guideline value}}{\text{Number of subsamples in composite}}$$

Hot spots

'Hot spots' are areas where there is localised elevated levels of lead in the soil. There can be a number of causes of hot spots, such as the area where lead contaminated building materials or paint removal waste have been dumped or burnt or other lead related activities and hobbies have regularly occurred in one specific location.

From a case-management perspective, a hot spot is of concern if it is associated with an exposure pathway (eg, play area, area frequented by pets, or being targeted by a pica case).

Ideally hot spots being targeted by a pica case will be identifiable from observation of the child's behaviour, visual contamination or unusual soil disturbance: however, soil sampling may still be required. It is critical that hot spots are considered when planning soil sampling. For a confirmed or suspected pica case, in addition to any composite sampling being done, a separate sample may be required from the localised area(s) where the case is eating soil. This is because high concentrations in one or more of the sub-samples making up the composite can be masked by a dilution effect of the other samples.

Appendix B of the *Contaminated Land Management Guidelines No. 5* (<https://environment.govt.nz/publications/contaminated-land-management-guidelines-no-5-site-investigation-and-analysis-of-soils/>) provides a method for calculating the spacing and minimum number of samples required to detect circular hot spots with 95% confidence.

Collecting and handling samples

Unless core samples are being taken, sample only the top 1.5 cm of soil. Collect about 100 g (half cup) of soil for each sample.

Any spoon, spatula or similar household or gardening implement can be used for surface sampling, provided it is thoroughly washed and dried before use, and then decontaminated again between samples to prevent cross-contamination. When decontaminating equipment, make sure not to contaminate any area that is to be sampled.

Should deeper samples be considered necessary (eg, to assess a vegetable garden at tuber depth or to confirm the depth of soil for replacement) then samples down to 0.5 m may be collected using trowel, push tubes, shovel or scoop.

For samples around a building perimeter, each sample should be taken about 50 cm from the face of the walls where paint and flakes are likely to fall. However, if there is a hard surfaced path adjacent to the wall, take the soil sample from the outer edge of the path where paint debris may have been washed, brushed or blown.

Sample containers must be clean and of an appropriate size and material. For soil lead samples, sealable plastic containers, such as screw top jars are acceptable. However, if there are any concerns about the use of sample containers this should be discussed with the analytical laboratory.

Recording sampling information

Each soil sample that is taken needs to be clearly and correctly labelled. Public health officers should use their assigned sampling initials and sequential numbering to generate an unique sample code. A laboratory form will need to be completed and sent with the samples to the laboratory.

It is important that the unique code, location and depth of each sample taken is clearly identified and recorded in a field notebook, on a map or in a site file. The date, time and name of the person taking the sample must also be recorded.

The information on location is required when reviewing the test results to assist in defining which areas are considered contaminated/unsafe areas from those areas that are not. As the person taking the samples may not be responsible for determining the extent of contamination, the information must be recorded in a manner that can be understood by other parties.

Appendix 2: Sample letters for paediatricians and medical practitioners

The first sample letter is an example of correspondence that may be sent to the general practitioner (GP) when a case is notified from someone other than the patient's GP (such as the laboratory or hospital). The consent of the case or the case's caregiver should be sought before contacting the GP (if he or she is not the notifier). The second letter is for a paediatrician and relates to blood lead levels over 0.96 µmol/l. Note that a copy is sent to the GP. Telephone contact should be made with a paediatrician to arrange urgent assessment if the child's blood lead level is ≥ 2.17 µmol/l.

Letter for paediatrician

Dear Dr

Elevated blood lead

Patient name

Date of birth

Address

.....

has been notified to the National Public Health Service as having an elevated whole blood lead level of µmol/l.

Whole blood lead levels of 0.24 µmol/l or greater are notifiable to the Medical Officer of Health under the Health Act 1956. A public health officer will investigate all such cases to determine the source of exposure and to assist in ensuring that levels fall.

Our involvement includes counselling about the effects of lead on health, and modification of nutrition, housekeeping, and hygiene to further reduce lead exposure. We will often undertake testing to determine the most likely sources and pathways of exposure to lead.

Our aim is to provide sufficient information and support to allow a managed reduction in blood lead. Blood tests at a sufficient frequency are crucial to demonstrate that lead levels are declining at an appropriate rate. We keep in contact with the case as part of our follow-up to ensure that progress is maintained.

In accordance with the Health New Zealand's guidelines for *The Environmental Case Management of Lead-exposed Persons* (2026) which state that children with whole blood lead levels over 0.96 µmol/l should be referred for assessment by a paediatrician your patient has:

- been referred (copy of referral letter is attached)
- not been referred.

If you would like to discuss this case or any issue relating to lead poisoning further please contact me.

Letter for paediatrician

Paediatrician's name

Address

.....

Dear Dr

Elevated blood lead

Patient name

Date of birth

Address

.....

.....

.....

has been notified to the National Public Health Service as having an elevated whole blood lead level of $\mu\text{mol/l}$. The Te Whatu Ora guidelines for *The Environmental Case Management of Lead-exposed Persons (2026)* state that children with whole blood lead levels over $0.96 \mu\text{mol/l}$ should be referred for assessment by a paediatrician.

I would appreciate if you could arrange to see as soon as convenient. In the interim, we will undertake an environmental assessment to identify sources and pathways of lead exposure in’s environment, and provide abatement advice as necessary. Our involvement includes counselling about the effects of lead on health, and modification of nutrition, housekeeping, and hygiene to further reduce lead exposure.

We will supply you with a copy of the environmental assessment report when it has been completed.

I would be grateful if you could provide both myself and Dr with a copy of your clinical assessment report.

If you would like to discuss this case or any issue relating to lead poisoning further please contact me or, Health Protection Officer, at this office.

Yours sincerely

Dr

Medical Officer of Health

National Public Health Service

cc: DrGeneral Practitioner

Appendix 3: Report sheets

These report sheets are designed to:

- identify likely sources and pathways of lead exposure
- determine if and where environmental samples should be collected
- help develop a risk management strategy.

Each set is based on information obtained by interviewing the principal caregiver (and if necessary other household residents), supplemented by visual observation of the environment and behaviour, spot testing for lead-based paint and examination of building, medical and other records (if required).

Copy the report sheets and adapt them for your own use

Save the Word document onto your hard drive so that the report sheets may be easily reproduced and adapted if necessary to suit individual cases. Users may also find it useful to copy parts of the text from the Graded Response Protocol and other material into the report sheets.

Suspected occupational exposures

Medical officers of health are required to advise WorkSafe New Zealand of work-related notifiable disease or hazardous substances injury (under section 199 of the Health and Safety and Work Act 2015). This requirement applies to cases of:

- a notification under section 74 of the Health Act 1956 of a notifiable disease that they reasonably believe arises from work; and
- a notification under section 143 of the Hazardous Substances and New Organisms Act 1996 (HSNO Act) of an injury caused by a hazardous substance that they reasonably believe arises from work.

To notify WorkSafe, please use the form: *"Notifications by medical officers of health - Notifications under section 199 of the Health and Safety at Work Act 2015"* (see Appendix 4). Please email the notification to: healthsafety.notification@worksafe.govt.nz.

The information from the notification is most useful if it includes the contact details of the patient's workplace and the patient's consent to pass that information to WorkSafe. WorkSafe can follow up with the business and, if necessary, visit the business to ensure safe work practices are being maintained.

Report sheets for lead exposure

Reference number for this investigation:

Your name:

1. Index case

Informant details

Date:

Contact person:

Address:

Phone:

Identification of index case

Name of index case:

Address:

Gender:

Date of birth:

Name of principal caregiver:

Address:

Phone:

Name and address of general practitioner:

Name and address of paediatrician:

Signs and symptoms

Why was the case notified?

Did the case have any symptoms suggestive of lead poisoning?

Was the case hospitalised (and why?) did the case receive chelation therapy?

What was the case's blood lead at the time of notification?

Has the case already been tested more than once?

If so, what were the results of these blood lead tests?

Date	Blood lead	Comments

Previous history

Is the case, or anyone else in the household, or a household pet an existing or previous case of lead poisoning? (If so, summarise key information from previous medical and public health records.)

Possible sources of exposure

Where does the case or principal caregiver think the case is getting the lead from?

Assessment 1: the index case

Persons at risk:
 Premises needing investigation:
 Probable sources and pathways of lead exposure:
 Assess severity of lead exposure (which will determine graded response)
 Assess need to rebleed the index case to confirm or update the blood lead level

Blood sampling (and breast milk sampling where necessary)

Person	Relationship to index case	Blood test results					
		Date	Result	Date	Result	Date	Result

2. People and environments at risk

Who usually lives at this address? (Include pets)
 Are there any preschool children who regularly visit? (List names, ages and relationships to index case.)
 How long has the index case lived at this address?

Complete the table for all addresses where the index case has previously lived for more than six months over the past two years

Address	Dates (from – to –)	Approximate age of dwelling (if known)	Comments about conditions / known renovation

Time the index case spends away from home, including formal early childhood services, informal care provided by a friend, neighbour or relative

Type of care	Location of care	Number of hours/week	Comments about age and condition of premises, known renovation

Home ownership

Do you rent or own your home?
If rented, get details of landlord.

Assessment 2: Persons at risk and implicated premises

Assess need to get a blood test for any other household residents or visitors for blood lead levels (include pets).

Assess need to investigate any premises other than the current address as possible sources of lead exposure (include previous residences; residences of friends, neighbours and relatives; early childhood services).

3. Paint and dust hazards

This section should be completed for each implicated premises.

Approximately what year was this house built? If unknown, was it built before 1945?

Over the past two years, has there been any renovation, repainting, revarnishing, window replacement, sanding or blasting of painted or varnished surfaces inside or outside this house? (If yes, describe dates, durations and nature of work in detail.)

Where does the case like to play or hide? (Include rooms, cupboards, decks, porches and outbuildings, eg, wendy house.)

Visually inspect the case's bedroom and principal play areas for lead paint hazards (chewed, worn, deteriorated or damaged paintwork, visible chips or dust in window wells,

on window sills, or on floor directly beneath windows). Do spot tests if age unknown or dated between 1945 and 1980.

Location (room, etc)	Evidence suggesting that paint is lead-based and non-intact

Each identified lead paint hazard should be assigned a code for ease of reference, and located on the accompanying sketch-map.

Assessment 3: Lead paint and dust hazards

Identify lead paint hazards based on:

- age of building
- condition of paint/varnish in areas where case spends time (sleeping, playing or hiding)
- history of recent disturbance of lead paint/varnish
- spot tests for lead paint (if necessary).

Assess need for laboratory testing of paint, varnish and/or dust, and if so where to sample.

Paint sampling plan:

Dust sampling plan:

Environmental sampling: paint

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

Environmental sampling: dust

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

4. Soil hazards

This section should be completed for every implicated premise. See answers to section 3 and transfer or cross-reference information as appropriate.

Over the past two years, has there been any renovation or repainting of exterior painted surfaces? (Include house exterior, garage, outbuildings, outdoor play equipment and fences.)

If so, is the approximate age of this paintwork known?

If pre-1980, describe dates, duration and nature of work in detail:

Where does case like to play outdoors?

Note soil/sand cover in principal play areas including sandpits and proximity to painted surface

Visually inspect exterior painted surfaces adjacent to principal play areas for paint condition, that is, provide evidence of non-intact lead paint – use spot testing if necessary.

Location	Evidence of hazard	Ground cover at this location

Each identified soil hazard should be coded for ease of reference and located on the accompanying sketch-map.

Other soil hazards

Is this premises located within 100 m of a major road with heavy traffic flows pre-1996 (leaded petrol)?

Is this premises located near a lead industry such as a smelter, battery recycler, radiator repair shop, or electronics manufacturer?

Has soil around the property been removed or dug over in the past year?

Is there a vegetable garden on the property? If so, is it close to a lead paint hazard?

Has painted wood been burned in a wood stove or fireplace on the property? If so, have the ashes been emptied onto soil, and where?

Assessment 4: Soil hazards

Assess likelihood of general contamination of the soil from stationary sources. Identify hot-spots resulting from damage to a deterioration of lead paint. Assess these hazards in relation to ground cover, time spent by case playing in the area, and whether or not the case has a pica habit.

Decide whether soil sampling is necessary, and if so where to sample. Note that this requires knowledge of whether the index case (or other case) has a pica habit. It also requires knowledge of possible historic contamination remote from current lead hazards.

Soil sampling plan:

Environmental sampling: soil

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

5. Uncommon lead hazards

5.1 Water

Which tap is most commonly used to obtain drinking-water? To prepare infant formula? Has new plumbing been installed in the past five years? (If so, get details) Is there any local knowledge that suggests that there may be old lead services still in use? Is the drinking-water supply plumbosolvent (soft and acidic)? Is it at risk of high lead levels? Consider whether the supply is private or from roof water. You may want to check the Drinking-water Register for New Zealand (maintained by The Water Services Authority | Taumata Arowai <https://hinekorako.taumataarowai.govt.nz/publicregister/supplies/>)

Assessment 5.1: Water

Assess whether lead in drinking-water could be a contributory source. If so, test first flush water from the indicated tap or taps.

Environmental sampling: water

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

5.2 Foods, cosmetics, medicines

Do you (ie, the family) often eat imported canned foods? (If so, ask to see cans.)

Does the case eat eggs from free range backyard chickens?

Do you eat home grown vegetables? (If so, assess exposure of the vegetable to lead in air and soil, extent of washing before eating.)

What containers are used to prepare, serve and store the case’s food? (Ask to see) Are any of them metal, pewter, crystal, soldered or glazed?

Does the case have a favourite mug, cup, bowl?

Are food and cooking/eating utensils stored under cover or exposed to dust? (Observe for evidence of visible dust traces.)

Are imported cosmetics such as kohl, suma or ceurix used in the home? (Ask to see.)

Are traditional medicines, home remedies, herbal treatments or bone-derived calcium supplements used in the home? (Ask to see.)

Does the case have access to any household chemicals or industrial products that contain lead? (Ask to see.)

Assessment 5.2: Foods, cosmetics, medicines, chemicals

Assess exposure (if any) from imported canned food, home-grown vegetables, cosmetics, traditional medicines, household/ industrial chemicals, cooking/ eating utensils.

Take samples for laboratory testing as required.

Environmental sampling: foods, cosmetics, medicines, chemicals

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

5.3 Hobbies

Dates, durations and activities over the past 12 months.

Has anyone in the household (over the past 12 months) removed paint or varnish while at home? (Include paint removal from cars, boats, bicycles, furniture, toys, woodwork.)

Soldered electrical parts while at home?

Cast lead models?

Applied glaze to ceramics or pottery?

Done stained glass work?

Painted pictures or jewellery using artist's paint?

Prepared shot for hunting or target shooting?

Participated in indoor rifle shooting? Outdoor rifle shooting?

Made fishing sinkers?

Done any car body repair work or battery breakdown in the garage or yard?

Assessment 5.3: Hobbies

Assess possible exposure of index case (or other household members) from these sources.

Plan any further investigation and laboratory testing with regard to hobby lead.

Environmental sampling: hobbies

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

5.4 Occupational (take-home) lead

Do caretakers, other adult household residents, or older siblings work with a lead process? (If yes, fill out table below)

- paint removal or repair/renovation of houses or other buildings
- demolition of buildings or structures such as bridges
- welding or other work involving cutting or melting metal (foundries, smelters)
- battery making or recycling
- plumbing
- radiation repair, panel beating or car painting
- paint manufacture
- pottery or jewellery making or repairing
- shipbuilding, repair or painting
- working in a glass factory
- working in a chemical plant that uses lead (whether a registered lead process or not).

Name	Relation to index case	Place of employment	Type of work	Probable lead exposure

If any probable occupational lead exposure identified, establish whether work clothes or footwear are worn home?

If so, are they kept separate? Are they laundered separately?

If any probable occupational lead exposure identified, establish whether the same motor vehicle used for commuting (or transporting workmates) is also used to transport household members?

Assessment 5.4: occupational take-home lead

Assess likelihood of occupational take home lead hazard, and possible exposure pathways. (Include clothing and footwear, car, hair and skin of worker.)

Decide on further investigation (if any) including laboratory testing. (WorkSafe may need to be involved.)

Environmental sampling: occupational take-home lead

Sample type and code	Location (sketch map)	Test results		
		Date–result–comment	Date–result–comment	Date–result–comment

Sketch map showing location of lead hazards, principal play areas, ground and floor cover, and sampling sites

(Include labelled photographs in envelope, if required.)

Envelope for photographs [attach]

6. Behavioural risk/protective factors

Note that section 6 needs to be completed separately for each case at risk. Intervention strategies can then be designed to meet the need of the most vulnerable case.

6.1 House cleaning routines

What cleaning equipment does the family have in the home? (Broom, mops and bucket, sponges and rags, detergent?) (Is a HEPA filtered vacuum cleaner needed?)

How often does the family:

- sweep the floors?
- wet mop the floors?
- vacuum the floors?
- wash the window sills?
- wash the window troughs?

Are the floor coverings smooth and cleanable?

What types of floor coverings are there, and where are they located? (Indicate on sketch-map.)

Assess the overall level of housekeeping

National ID: 18341	Published: 11/02/2026	Review due: 19/12/2028	Page: 120 of 136
--------------------	-----------------------	------------------------	------------------

Adequate	Borderline	Inadequate
No visible dust on most surfaces	Slight dust build-up in corners	Heavy dust build-up in corners
Evidence of recent vacuuming of carpet	No evidence of recent vacuuming of carpets	No evidence of recent vacuuming of carpets
No matted or soiled carpets	Some matted or soiled carpets	Matted or soiled carpeting
No debris or food particles scattered about	Some debris or food particles scattered about	Debris or food particles scattered about
Few visible cobwebs	Some visible cobwebs	Visible cobwebs
Clean kitchen floor	Slightly soiled kitchen floor	Heavily soiled kitchen floor
Clean door jambs	Slightly soiled door jambs	Heavily soiled door jambs

Assessment 6.1: house cleaning factors

Assess whether cleaning equipment appears adequate.

Assess whether cleaning routines appear adequate.

Assess whether floor coverings make it difficult to maintain a low dust environment.

6.2 Behavioural risk/protective factors: hygiene

Does the (index) case:

- suck their thumb or fingers?
- bite their nails?

Assess the general state of cleanliness of the case. Are hands or face visibly dirty? Are finger nails long?

Does the case put any painted object into their mouth? (If yes, give details – directly observe if possible.)

Does the case chew on any painted surfaces? (If yes, get details. Ask about cot, window sills, furniture, railings, door moulding, broom handles.)

Does the case chew on any putty around windows?

Does the case eat paint chips or pick at painted surfaces?

Is the paint in the case's bedroom and principal play area intact?

Does the case eat soil (dirt)? If so, about how often and how much? (Directly observe if at all possible.)

Does the case have a favourite play area in the yard or garden?

Does this area have patches that are uncovered ie, bare soil is exposed?

How close is this area to the house or other painted structure? (Garage, outbuildings, fence)

Does the case chew or eat printed materials such as newspapers, magazines or books?

Does the case put any soft metal objects in its mouth? (Ask about lead or pewter toys, jewellery, containers, graphic materials, hobby items.)

Is the case commonly fed while playing on the floor? Outside?

Does the case pick up fallen food items from the floor or ground and eat them?

Does the household have a dog or cat that could track contaminated soil into the house?

If so, where does the pet sleep? Does it have access to the case's sleeping, eating or principal play areas? Does the case directly lick or kiss it? (Directly observe if possible.)

How often are pet dogs washed?

Assessment 6.2: hygiene and case behaviour

Assess the extent to which the case's mouthing behaviour, hand-to-mouth activity, play behaviour and feeding behaviour could be contributing to lead exposure.

Assess the extent and nature of pica (soil eating).

Assess the contribution of pet animals to case exposure.

Assess the extent and modifiability of existing hygiene practices (eg, hand washing, nail clipping).

6.3 Behavioural risk/protective factors: diet

Is the case being breastfed?

How many meals per day does the case eat (including breast milk or solid foods)?

How much milk does the case drink?

Are other dairy products eaten?

How much meat, chicken and seafood does the case eat?

How many servings of fresh vegetables or fruit does the case eat on a typical day?

Does the case drink tea?

What about other traditional foods?

Assessment 6.3: diet

Assess the nutritional status of the case (especially iron-status). This should be done by, or in consultation with, a dietician and may require blood test to check iron status.

Assess the frequency of meals.

Assess the extent to which the case's diet complies with the age-appropriate Eating and Activity Guidelines, including the *Food and Nutrition Guidelines* (ie, low saturated fat, sufficient phosphate, calcium, iron and zinc). Refer to:

<https://www.tewhatauora.govt.nz/health-services-and-programmes/nutrition/eating-and-activity-guidelines>

Decide on further investigations, need for dietary change or dietary supplementation.

7. Action plan

Temporary relocation
Action sought from landlord
Paediatric referral

Environmental abatement

Abatement work recommended	Sketch map reference	Date completed	Observed Y/N	Clearance sampling (date)	Comments

Behaviour modification: house cleaning routine

Behaviour recommended	Frequency	Date started	Date checked	Comments

Behaviour modification: hygiene/case behaviour

Behaviour recommended	Frequency	Date started	Date checked	Comments

Behaviour modification: diet

Behaviour recommended	Frequency	Date started	Date checked	Comments

8. Situation review

Summarise assessment, advice given, compliance, outcome evaluation)

Initial visit
First follow-up visit or other contact
Second follow-up visit or other contact
Further follow-up visits or additional contacts

Appendix 4: Work injury notification form

June 2025

WORKSAFE
Mahi Haumarū Aotearoa

FORM

Notifications by medical officers of health

Notifications under section 199 of the Health and Safety at Work Act 2015

Please send each notification in a separate email

Email: healthsafety.notification@worksafe.govt.nz

Mandatory information

Pursuant to section 199 of the Health and Safety at Work Act 2015 (HSWA)

The following information is required by law to be provided to WorkSafe New Zealand. Individual/patient consent is not a prerequisite in supplying the information in this section.

WorkSafe may pass the notification to another regulatory agency under HSWA if the notification falls within their area of responsibility (see s 197(1)(a)(ii) HSWA and Information Privacy Principle 11(1)(a))

Type of notification received:
<input type="radio"/> Section 74 of the Health Act 1956 of a notifiable disease (that you reasonably believe arises from work)
<input type="radio"/> Section 143 Hazardous Substances and New Organisms Act 1996 of an injury caused by a hazardous substance (that you reasonably believe arises from work)
Full name of person:
Nature of disease or injury:
Blood lead level ($\mu\text{mol/L}$): (if applicable)

Discretionary information Section 197 of HSWA

The following information is not required by law to be provided to WorkSafe. Provision of the below information to WorkSafe is discretionary. WorkSafe seeks this information in order to enable it to carry out its functions, duties or powers. If the information requested below is provided to WorkSafe, it must be provided with the relevant individual's consent.

Contact details of medical officer of health

This information is collected to enable WorkSafe to contact you if further information is needed from you, in order to enable WorkSafe to monitor and enforce compliance with health and safety legislation.

Name:
Mobile phone:
Work phone:
City/town:
Geographical region:

Patient workplace information

This information is being collected by WorkSafe for purposes of monitoring and enforcing compliance with health and safety legislation.

Name of workplace:
New Zealand Business Number (NZBN): (if known)
Address of workplace:
Two or more cases in the workplace:
<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Not sure/no information
Describe hazard present in the workplace:

WSNZ_4464_LIN 25



worksafe.govt.nz 0800 030 040 1/2

Notifications by medical officers of health

Patient demographic information

This information is collected for purposes of research, and for purposes of analysing and publishing statistics in relation to work health and safety. The relevant individual will not be identified in any publication.

Date of birth: / /

Gender:

- Male Female Prefer not to say/not specified
 Another gender: (please advise)

Ethnic origin:

- NZ Pakeha/European Māori
 Other European Samoan
 Tongan Cook Island Māori
 Niuean Chinese Indian
 Other: (please advise)

Patient objected to providing some or all s197 information: Yes No

Information provided under s197 subject to any conditions

Conditions can relate to the storage and use of, or access to, anything provided; and the copying, returning, or disposing of copies of any documents provided. Yes No

If yes, specify conditions:

Type of work

Note in some situations more than one type of work may be applicable

This information is collected for purposes of research, and for purposes of analysing and publishing statistics in relation to work health and safety. The relevant individual will not be identified in any publication.

Type of work: (select all that apply)

- Accommodation and Food Services
 Administrative and Support Services
 Agriculture
 Aquaculture
 Arts and Recreation Services
 Construction
 Diving
 Education and Training
 Electricity and Gas
 Financial and Insurance Services
 Fishing, Hunting and Trapping
 Forestry and Logging
 Health Care and Social Assistance
 Information Media and Telecommunications
 Manufacturing
 Mining - Minerals
 Mining - Petroleum
 Mining - Other Services
 Professional, Scientific and Technical Services
 Public Administration and Safety
 Rental, Hiring and Real Estate Services
 Retail Trade
 Transport, Postal and Warehousing
 Water and Waste Services
 Wholesale Trade
 Other services or types of work: (please specify)

Appendix 5: Health advice for indoor target clubs

What is lead poisoning?

Lead poisoning occurs when blood lead levels are higher than is considered safe for health. Under the Health Act 1956, blood lead levels greater than or equal to 0.24 µmol/L must be notified to the Medical Officer of Health by your doctor. This level is considered potentially unsafe for members of the public, particularly children and pregnant women, because lead can interfere with the development and functioning of the brain and other organs in developing children.

Symptoms

The symptoms of lead poisoning may go unnoticed until blood lead levels are very high because they are very common and non-specific. Symptoms can include the following:

- Effects on the brain – mood change (depression, irritability), memory loss, sleep disturbance, headaches, difficulty concentrating, tingling and numbness in fingers and hands.
- Effects on the digestive system – lack of appetite, nausea, diarrhoea, constipation, stomach pains and weight loss.
- Other effects – kidney damage, reduction in sperm quality and number, miscarriage and anaemia.

What causes lead poisoning?

At home

The main causes of lead poisoning in people who are not exposed to lead at work are indoor shooting; casting of lead bullets, fish sinkers and diving weights; paint-stripping on houses built pre-1980s; and consumption of herbal medicines and Ayurvedic medicines which contain lead. Non-occupational sources of lead exposure are investigated by the National Public Health Service.

At work

Various occupations involve exposures to lead and cases of occupational lead poisoning are investigated by the WorkSafe New Zealand. Examples of occupations where lead

exposure may occur include: painting, smelting, plumbing, panel beating, battery manufacture, soldering, and radiator repairs.

Why are indoor shooters at risk of lead poisoning?

Research has shown that users of indoor firing ranges are at risk of exposure to high levels of lead. Cases of lead poisoning investigated by public health have also shown that indoor shooting is often associated with raised blood lead levels. This is generally because lead fumes and dust generated by shooting may be breathed into the lungs or swallowed, and then adsorbed into the blood. Lead contamination from hands may be transmitted to food items and cigarettes – where it can be swallowed. Lead dust may also be taken home on clothing worn at the shooting range and result in others being exposed at home. It is particularly important not to carry lead home on your body and clothing to an environment occupied by pregnant women and children aged six and younger (who are particularly sensitive to lead poisoning).

What can you do to prevent lead poisoning?

A number of things may be done to reduce your exposure to lead. There are things that you should do as an individual, and these are listed below. There are also things that those who manage the firing range should do, such as:

- (1) ensuring adequate ventilation so that lead contaminated air flows away from shooters and is extracted safely
- (2) ensuring adequate hand washing facilities are available
- (3) ensuring that lead dust that accumulates via shooting is regularly removed using a HEPA filter vacuum cleaner or by wet mopping – these methods prevent lead dust being spread further or breathed in by those doing the cleaning.

Monitoring

If you are a shooter who attends an indoor shooting club frequently, eg, one or more times per week, you should have your blood lead level monitored by your doctor at least once a year. This should be done during the shooting season when blood lead levels are likely to be highest. If your lead level is raised, public health will ring you and help you to identify and manage your exposures to lead.

Hygiene

After shooting you may have lead residues on your hands, other exposed parts of the body, your clothes, and your shooting gear. If these are not cleaned, they will be an ongoing source of lead which you may breathe in or swallow. To avoid ongoing contamination, you should wash your hands after shooting, particularly before eating, drinking or smoking. Contaminated clothing should be put in a plastic bag for transporting home and stored and laundered separately from other clothing. Shooting vests and mats should be washed regularly using a phosphate detergent, and washed and stored separately from other garments. Avoid shaking contaminated garments (which releases lead dust). Hair may be covered during shooting or should be washed as soon as possible after shooting. It is particularly important not to carry lead home on your body and clothing if pregnant women and children may be exposed to lead.

Personal Protective Equipment (PPE)

Some shooting clubs advise the use of masks and other personal protective equipment (PPE) when shooting.

Nutrition

Diet and eating patterns can help in reducing the amount of lead absorbed into your body. Eating before shooting may help reduce lead levels because studies have shown that full stomachs are less able to absorb lead. Foods rich in calcium and iron help reduce the amount of lead that is absorbed from the gut into the bloodstream. Adequate vitamin C levels are also important in increasing iron absorption. Advice on healthy eating should follow the *Eating and Activity Guidelines* (Ministry of Health 2020). A range of guidance documents are available at: <https://www.tewhatauora.govt.nz/health-services-and-programmes/nutrition/eating-and-activity-guideline>.

Shooting behaviours

The more frequently you shoot, the more lead you are likely to be exposed to, and exposure will also depend on where and how you shoot, PPE worn, ventilation, and any other activities or behaviours that affect dust levels. Casting of bullets is a particular concern due to personal handling of lead and lead-contaminated equipment; and inhaling lead fumes.

Range cleaning

If you are involved in range cleaning and maintenance, your risk of lead poisoning will be increased due to higher exposures to lead, particularly if these activities result in dust being generated. Follow the advice above and use HEPA filter vacuums, wet mopping and PPE when cleaning.

What do you do if you think you have lead poisoning?

- If you have any symptoms, please ensure that you see your doctor. Your symptoms may not be due to lead poisoning but you should tell your doctor of any lead exposures that you may have experienced, including indoor shooting, so that your doctor can decide whether or not you should have a blood test for lead.
- If your blood lead level is raised, the Medical Officer of Health is notified by the laboratory. An officer from public health will ring you and work through a questionnaire with you to find out how you are coming into contact with lead.
- Using the results of the questionnaire, a public health officer will offer you advice on how to reduce your exposures to lead. We will also work with you and your doctor to manage your blood lead level until it returns to normal. When we find that a number of people are being exposed to lead from the same place, we will offer advice on how the exposure may be reduced so that others are not exposed in the future.

Appendix 6: Minimising lead exposure in target club ranges

Public health advice for operators

The following are recommended as part of best practice design and operation of indoor shooting ranges. There is no one-size-fits-all solution as every range is different and requires its own design solutions. The design concept of 'dirty' areas and 'clean' areas is useful. Please note that it is difficult to assess indoor shooting ranges for risks from lead exposure and to develop pragmatic, workable solutions. The regulatory agency for use of land and requirements related to buildings is the territorial authority for the location, ie, the local council. It is recommended that early consultation occurs with the relevant council to avoid expensive mistakes.

These recommendations also include safety advice for shooters. Shooting ranges and clubs should educate shooters about the potential harm of lead exposure and promote mitigation strategies via information pamphlets, club newsletters, email updates and website information. This document includes a reference list to many other sources of information.

Recommendations

Shooting club committees, range officers and shooters at indoor shooting ranges should take the following steps to protect themselves from risks of elevated lead exposure:

When designing or renovating a shooting range (to minimise lead exposure)

- Ensure adequate ventilation and air filtration systems are installed in consultation with an expert third party. Ventilation changes may need council consent. (1)
- Where possible, use bullet traps that minimise lead dust generation. Some newer traps do away with the need for regular cleaning. Repeated misting with water using a garden sprayer will help to keep the dust down.
- In the 'dirty' area, facility walls, ceilings, floors and all fixed structures, partitions, chairs and tables should have washable, smooth surfaces that are easy to keep clean.
- Avoid dust traps on ceiling beams or roof trusses and promote aerial separation of the 'dirty' area from 'clean' areas, eg, by self-closing, draught-proof doors.

Operating a shooting range (to minimise lead exposure)

- Discourage eating, drinking or smoking in the firing range 'dirty' area. (2, 3, 4)
- Ensure that shooters have ready access to hand washing facilities, and are advised to wash their hands immediately following their shooting session.
- Consider the use of lead free ammunition for indoor ranges.
- Consider limiting the number of shooters per session.
- Advise users to wear dust masks whilst shooting, to avoid exposure to excess lead. (18, 19)

Cleaning and maintenance of 'dirty' areas

- Disposable overalls, gloves and masks should be worn at all times during cleaning. (5)
- Disposable overalls, gloves and masks should be worn during indoor repair and maintenance work. (5)
- Young persons of school age (defined as 15 and under) and women of childbearing age should not participate in cleaning or maintenance of 'dirty' areas.
- Laminated posters on personal hygiene (especially on hand washing and not eating, drinking or smoking in the firing range) should be displayed prominently at ranges.
- A regular monitoring programme should be established to ensure the correct operation of ventilation systems with a written record kept of checks conducted. Ventilation systems need regular maintenance and cleaning (including filter replacement if required) according to manufacturers' advice. (7, 8, 9, 10, 11, 12)
- Ensure fan and ventilation systems are always turned on and fully functional when the range is in use.
- Anyone participating in cleaning needs to have adequate training on ways to minimise lead dust exposure and in the use of appropriate personal protective equipment (PPE). (7, 13)
- A roster system should be created to rotate range officers and shooters to minimise lead exposure.
- Only use wet mopping or HEPA-filter vacuuming instead of dry sweeping when cleaning the floor in 'dirty areas'. Never dry sweep or use cleaning techniques that raise dust. (5, 13)
- When cleaning horizontal surfaces (other than the floor) in 'dirty' areas, always use wet squeegees or wipes. (5, 13)
- If bullet traps needs to be emptied, debris should be emptied into sealed plastic bags and repeatedly misted with water to avoid raising dust.

- Contaminated materials (ie, wiping cloths, filters, mop heads and contaminated back stops/soil, etc) should be safely disposed to landfill by a Department of Labour WorkSafe approved cleaning contractor – as hazardous material.
- If contractors are hired to clean premises or remove lead contaminated back stops/soil, then they must follow best practice guidelines, ie, from WorkSafe New Zealand and/or territorial authorities.

Information for shooters

Shooters regularly attending an indoor shooting range; shooters who cast their own bullets and shooters who are involved in regular range housekeeping or maintenance activities should consider asking their GP to monitor their blood lead level. These persons may have raised levels of lead in their blood, where indoor shooting could be a contributing lead exposure risk. (14, 16, 17)

Environmental management

- Shooting range management should also consider how to dispose of waste that contains lead residues to minimise the impact of lead pollution on the environment.
- Ranges and clubs should nominate a health and safety representative, often the range officer, who is trained to minimise lead exposure and tasked to actively raise awareness amongst shooters of ways to decrease lead exposure. For example, they could initiate the production of advice, policies, procedures, and programmes specific to indoor shooting ranges according to relevant standards and legislation.
- Shooters should use personal protective equipment (PPE) and consider regular blood tests to check their lead levels. (14, 15)
- Clubs should advise shooters to consult a doctor if concerned about their health. The public health officer will contact members with raised blood lead levels and discuss how lead exposures may be reduced.
- Lead exposure resulting from work activities is a matter for WorkSafe New Zealand. (16, 17)

Should you require any further information about dealing with environmental exposure to lead, please contact the Health Protection Officers at your local Public Health Service (contact information can be found at <https://info.health.nz/contact-us/contact-specific-health-nz-teams>).

References

1. Kinsky H. 2005. A General Overview of Indoor Shooting Ranges in Germany. In: World Forum on the Future of Sport Shooting Activity, editor. Workshop on indoor

shooting ranges: responsible care of range environment. Rome, Italy: World Forum on the Future of Sport Shooting Activity, pp 41–4.

2. Novotny T, Cook M, Hughes J, et al. 1987. Lead exposure in a firing range. *Am J Public Health* 77(9): 1225.
3. Fowles J, Bates M. 2000. *The Chemical Constituents in Cigarettes and Cigarette Smoke: Priorities for Harm Reduction: A Report to the New Zealand Ministry of Health*. Porirua, New Zealand: Epidemiology and Toxicology Group ESR: Kenepuru Science Centre.
4. Jones BL. 1999. *Reducing Lead Contamination and Exposure on Military Firing Ranges through the Practical Application of Ballistic Containment Systems (4th edition)*. California: United State Marine Corps, Department of the Navy.
5. National Institute for Occupational Safety and Health (NIOSH). 1975. *Lead Exposure and Design Consideration for Indoor Firing Ranges*. Washington DC: National Institute for Occupational Safety and Health (NIOSH), US Department of Health, Education and Welfare (HEW) 1975. Report No. Pub. No. (NIOSH): 76-130.
6. Shannon M. 1999. Lead poisoning in adolescents who are competitive marksmen. *N Eng J Med* 341: 852.
7. Novotny T, Cook M, Hughes J, et al. 1987. Lead exposure in a firing range. *Am J Public Health* 77(9): 1225.
8. Fischbein A, Rice C, Sarkozi L, et al. 1979. Exposure to lead in firing ranges. *JAMA* 241(11): 1141.
9. Gulson B, Palmer J, Bryce A. 2002. Changes in blood lead of a recreational shooter. *The Science of the Total Environment* 293(1-3): 143–50.
10. Landrigan PJ, McKinney AS, Hopkins LC, et al. 1975. Chronic lead absorption: result of poor ventilation in an indoor pistol range. *JAMA* 234(4): 394–7.
11. Crouch KG, Peng T, Murdoch DJ. 1991. Ventilation control of lead in indoor firing ranges: inlet configuration and booth and fluctuating flow contributions. *Am Ind Hyg Assoc J* 52(2): 81-91.
12. Factsheet from the National Public Health Service in regards to lead hazards and indoor shooting ranges. Published by Public Health Services, Palmerston North. URL:
http://www.midcentraldhb.govt.nz/HealthServices/PublicHealth/healthprotection/Documents/2009Aug_SmallBore_FactSheet.pdf (accessed 5 September 2023).

13. Compton FS. 2005. Control of Lead Dust and Unburnt Propellant in Indoor Ranges.
14. George PM, Walmsley TA, Currie D, et al. 1993. Lead exposure during recreational use of smallbore rifle ranges. NZ Med J 106(965): 422-4.
15. Anthony M Gregory. 1990. Risks of lead poisoning in firearms instructors and their students. The Aslet Journal 4(2).
16. https://info.health.nz/health-topics/keeping-healthy/healthy-homes-environments/hazardous-substances/lead/lead-based-paint_ (accessed 10 February 2026 Health New Zealand) and <https://info.health.nz/health-topics/keeping-healthy/healthy-homes-environments/hazardous-substances/lead/lead-poisoning> (accessed 10 February 2026).
17. <https://www.tewhātuora.govt.nz/health-services-and-programmes/environmental-health/hazardous-substances/lead> (accessed 29 October 2025).
18. Bonanno J, Robson M, Buckley B, et al. 2002. Lead exposure at a covered outdoor firing range. Bulletin of Environmental Contamination and Toxicology 68(3): 315–23.
19. Tripathi R, Sherertz P, Llewellyn G, et al. 1991. Lead exposure in outdoor firearm instructors. Am J Public Health 81(6): 753.

Glossary

µg	microgram, one millionth of a gram, sometimes written mcg
µm	one millionth of a metre, sometimes called a micron
µmol	micromole
Abatement	the removal or significant reduction of a source of hazard and intervention to reduce exposure to a hazard
Certified Contractor – Lead-based Paints	a registered master painter certified in the management of lead-based paint by the Master Painters New Zealand Association
ATSDR	Agency for Toxic Substances and Disease Registry
Binder	solid ingredients in a coating holding the pigment particles. Binders are based on oil, alkyd, acrylic, latex and epoxy. The nature and amount determines the coatings performance
Blood lead	blood lead level in micromoles of lead per litre of blood, µmol/l
CDC	Centers for Disease Control
Ceurix	a cosmetic, which may contain lead particularly if an imported brand
Chalking	photo-oxidation of paint binders causing powder on the film surface
Clearance	confirmation of acceptable levels of contamination
Clearance and action levels	in the US HUD guidelines and the US EPA Proposed Rule the clearance levels are the levels of lead in dust and lead in soil that abatement seeks to achieve. The levels are also action levels, ie, the levels which, if exceeded, require further action
Decilitre	one tenth of a litre or 100 millilitres
Dust lead concentration	the proportion of the mass of lead in a known mass of dust
Dust lead loading	mass of lead in dust per unit area, measured in µg/m ² of dust bearing area
Dust loading	mg dust/m ²
GP	General Practitioner
HEPA filter	high-efficiency particulate air filter capable of removing particles of 0.3 µm or larger from air at 99.97 percent efficiency
Hg	mercury
HSNO	Hazardous Substances and New Organisms Act
IANZ	International Accreditation New Zealand (formerly known as TELARC)
IARC	International Agency for Research on Cancer
Index case	case that is the subject of investigation

Kohl	a cosmetic, which may contain lead particularly if an imported brand
LBP	lead-based paint that contains by dry weight 0.5 mg/cm ² or 2500 µg/g or more of lead
LIM	Land Information Memorandum
/	litre, sometimes written L
MAV	Maximum Acceptable Value
mg	milligram or one thousandth of a gram
Micron	one millionth of a metre (µm)
NES	Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011.
PbB	lead in blood; measured in micromole of lead per litre of blood, µmol/l
PbD	lead in dust; measured in microgram of lead per gram of dust µg/g (same as mg/kg or ppm)
PbS	lead in soil; measured in microgram of lead per gram of soil, µg/g (same as mg/kg or ppm)
Pigment	insoluble fine particles giving paint colour and opacity
PPE	personal protective equipment
ppm	parts per million by mass
Primary prevention	measures taken to prevent hazardous conditions arising
Secondary prevention	measures taken to remove a hazard and correct or reverse harmful effects
Suma	a cosmetic, which may contain lead particularly if an imported brand
SUSDP	Standard for the Uniform Scheduling of Drugs and Poisons
Tertiary prevention	providing medical treatment to a person with elevated blood lead levels to prevent more serious injury or death
US EPA	US Environmental Protection Agency
US HUD	US Department of Housing and Urban Development
Window trough	that part of the window sill below both the upper and lower vertical sliding sashes of sash windows, or the area of the sill or frame covered by a closed casement or top hung window
WorkSafe	WorkSafe New Zealand
uPVC	un-plasticised polyvinyl chloride
XRF	X-ray fluorescence