Public Health England

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Lead Exposure in Children Surveillance System (LEICSS) annual report, 2018

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This report summarises the surveillance of lead exposure in children in England from 1 January to 31 December 2018.

A case is defined as a child:

- with a blood lead concentration ≥0.48µmol/L (equivalent to ≥10µg/dl), as detected in a UK Accreditation Service (UKAS) accredited biochemistry or toxicology laboratory
- aged under 16 years at the time of first elevated blood lead concentration
- resident in England.

Key points

- 45 cases of lead exposure in children were notified to Public Health England (PHE) in 2018
- most cases (73%) were directly notified to LEICSS by participating laboratories; 11 were notified to PHE through other routes
- the median delay between a specimen being drawn and a case being entered onto HPZone for transfer to the local HPT to initiate public health action was 8 days
- the number of cases detected was lower than the expected incidence of lead exposure based on international population survey data
- the average detection rate for England between 2015 and 2018 was 3.76 cases per million children aged 0-15 years, although there was large regional variation between PHE Centres
- cases were typically 1-4 years of age, male, and resident in more deprived areas
- the median blood lead concentration of cases was 0.82µmol/L (16.98 µg/dL) in 2018.

Key messages and recommendations

- lead is a persistent environmental contaminant that can cause toxicity even at low blood lead concentrations - there is no safe lower threshold of exposure
- children exhibiting pica* or more hand to mouth behaviour in environments with lead hazards are likely at highest risk of exposure
- clinicians should be aware of important sources of lead exposure, children most at risk, and presenting symptoms/signs of exposure
- Public Health England is proposing that the public health intervention level for lead is lowered from ≥10µg/dL (≥0.48µmol/L) to ≥5µg/dL (≥0.24µmol/L) for children under 16 years and for pregnant women; PHE will work with stakeholders and then advise from when these changes will take effect, which is anticipated in 2020
- cases with a blood lead concentration above the public health intervention level for lead should be notified to PHE health protection teams for active public health case management

* The persistent ingestion of non-nutritive substances at an age where this is developmentally inappropriate

Background

Exposure to lead can result in severe multi-system toxicity. How this toxicity manifests depends on both the blood lead concentration (BLC), and how rapidly BLC rises. Overt manifestations of toxicity (i.e. lead poisoning), such as anaemia or abdominal pain, accompany higher lead concentrations, eg BLC>1.93µmol/L (>40µg/dl)* [1]. Lead exposures resulting in a lower BLC may not cause such apparent symptoms, but still cause harm, particularly to the central nervous system. Decreased intellectual function and possibly other neuro-behavioural problems such as shortening of attention span and disruptive behaviour are associated with BLCs even below 0.48µmol/L (10µg/dl) [1,2]. Timely removal or abatement of the exposure source is the mainstay of case management, but symptomatic children, and children with blood lead concentration greater than 1.93µmol/L may also require chelation therapy [2].

Successful primary prevention efforts – targeted at reducing the use of lead in paints and fuels, regulation of lead concentrations in drinking water, planning controls and remediation of lead in soil, and control of industry emissions – have resulted in a fall in BLC in children. However, lead is a persistent contaminant, therefore children can still be exposed to lead already in the environment. Since the removal of lead from petrol, ingestion rather than inhalation has been the most common route of exposure in high income countries, particularly from flakes and dust from exposed leaded paint [2]. (Leaded paint had wide domestic use in the UK before gradual withdrawal from the 1960s onwards [3] and was banned for sale in 1992.)

Children with developmental disorders have been found to have higher blood lead concentrations than other children [4]; such children are at higher risk of exposure due to increased mouthing (or “pica”) behaviour [5] leading to increased ingestion of lead, eg from paint flakes, or lead in soil. Iron deficiency may further increase susceptibility to lead toxicity [6]. Other important potential routes of exposure in children are ingestion of lead-contaminated water, contaminated soil or dust, fuel-containing lead vehicle emissions, herbal medicine preparations, consumer products not meeting regulatory standards (eg paint on toys, lead crystal glassware) and secondary exposure from parental hobbies or occupations (eg resulting in children being exposed to lead dust on work-clothing) [1].

There are no recent survey data estimating how many children in England are exposed to lead, but international population survey data may be used for estimates; a survey conducted in France in 2008/9** [7] estimated 0.09% of 1-6 year-olds had a BLC ≥0.48µmol/L (≥10µg/dl), and 1.5% a BLC ≥0.24µmol/L (≥5µg/dl). A survey in the USA in 2013/14 [8] estimated 0.5% of 1-5 year-olds had a BLC ≥0.24µmol/L (≥5µg/dl).

* Both µmol/L and µg/dL units are commonly used internationally to express blood lead concentrations, where 1 µg/dl = 0.0483µmol/L. Divide the concentration in µg/dl by 20.7 to obtain the concentration in µmol/L.

** France banned white lead-based interior paint in 1909; thus exposures from this source would be expected to be lower than in the UK.

Comparison with historic data strongly suggests a substantial fall in average BLCs [8]. However, population lead exposure is strongly influenced by setting, so these findings give only a broad indication of the potential situation in England.

Lead exposure is diagnosed by a blood test to measure the blood lead concentration. Because signs and symptoms of lead exposure are non-specific, an evidence review for population screening was carried out by the National Screening Committee in 2018. A systematic population screening programme was not recommended [9] because of concerns about testing and treatment and the lack of up to date population data (alongside evidence of a steady decline in lead exposure over time). Case detection therefore depends on clinicians having a high clinical suspicion, for example due to the home circumstances of the child increasing the risk of lead exposure, and subsequently ordering a blood test. Surveillance of cases identified by clinicians offers a means of gathering intelligence to guide public health action to prevent further cases of exposure.

The Lead Exposure in Children Surveillance System (LEICSS)

Public Health England (PHE) coordinates LEICSS, a national surveillance system for children resident in England. Formal surveillance of lead exposure in children in England was initiated in 2010 by the Surveillance of Raised Blood Lead Levels in Children (SLiC) study, a joint research project between the British Paediatric Surveillance Unit and the Health Protection Agency (the forebear to PHE). The SLiC study authors recommended implementation of a laboratory-based surveillance system in order to facilitate timely public health management of cases of lead poisoning in children [10]. A pilot system, the Lead Poisoning in Children (LPIC) surveillance system, was therefore instigated in 2014. LPIC was then permanently implemented in 2016 following successful evaluation of the pilot, and its name changed to LEICSS to recognise broader aims of prevention of lead exposure in children, in addition to the rapid recognition of cases of lead poisoning.

A PHE working group oversees LEICSS management, and a steering group with additional representatives from participating laboratories, academia, and NHS clinical toxicology, oversee system aims and development (see Steering and Working Group Members below). LEICSS is one component of the Environmental Public Health Surveillance System (EPHSS) operated by PHE as part of Environmental Public Health Tracking, and the steering group and working group report to the PHE Environmental Public Health Tracking Board. More information about Environmental Public Health Tracking and EPHSS can be found here:

https://www.gov.uk/government/publications/environmental-public-health-surveillance-system.

LEICSS aims are:

- to facilitate timely public health action for individual cases, as the mainstay of treatment for cases of lead exposure is rapid removal of the putative source of exposure.
- the system should also meet population level surveillance objectives, to inform public health action to reduce the incidence of lead exposure in children in England, such as by identifying at risk geographic areas or populations, and identification of current and emerging sources of exposure.

Case reporting to LEICSS

LEICSS is a passive surveillance system that integrates reports of incident (newly detected) cases of lead exposure in children from 2 sources:

- cases reported to PHE directly from a testing biochemistry/toxicology laboratory, or
- searching HPZone* for cases first reported from a non-PHE source (eg the managing clinician or an environmental health officer) to a local PHE Health Protection Team (HPT)**, or from other PHE departments (eg PHE CRCE Environmental Hazards and Emergencies) and not reported to LEICSS by laboratories participating in surveillance

Case notification to PHE is voluntary but encouraged for case management and surveillance purposes.

* HPZone is the public health case management system used in England by PHE Health Protection Teams when investigating and managing public health threats to their local populations.

** HPTs are frontline units responsible for investigating and managing public health threats to their populations.

Case reports from biochemistry and toxicology laboratories

Reports of cases meeting the following case definition are referred to as 'laboratory-detected' cases.

A laboratory-detected case is defined as a child:

- with a blood lead concentration ≥0.48µmol/L (equivalent to ≥10µg/dl), as detected in a UK Accreditation Service (UKAS) accredited biochemistry or toxicology laboratory
- aged under 16 years at the time of first elevated blood lead concentration
- resident in England.

LEICSS surveillance staff enter case details onto HPZone following notification. The relevant local HPT is then alerted to investigate and manage the case. This route of notification to the investigating HPT has been found to be more timely than waiting for notification from other sources involved in treating the case eg the managing clinician [11].

'HPZone-detected' cases

HPZone-detected cases are those that are/were:

- managed as cases diagnosed with 'toxic exposure to lead' by a health protection team based in England
- aged under 16 years at the time of notification to the health protection team
- resident in England
- not initially notified to LEICSS by a participating biochemistry/toxicology laboratory

Blood lead concentration data are not routinely recorded on HPZone in a way that makes them available for analyses by LEICSS for these cases.

The Supra-regional Assay Service (SAS) Trace Elements laboratories network, and other reporting laboratories

A group of highly specialised diagnostic laboratories, the SAS, provide a referral network for specialised laboratory investigations in the UK. Blood lead concentration is measured in six SAS Trace Elements laboratories in England, and it is estimated they perform the vast majority of such tests nationally. All six SAS laboratories participate in LEICSS, and a partnership between the SAS-associate laboratory in Wales (Cardiff Toxicology Laboratory) has been developed to alert LEICSS of England residents whose blood lead concentration may be determined in Cardiff. Other, non-SAS but accredited laboratories have also agreed to report cases to LEICSS; these are typically located in larger NHS Trusts or are private laboratories.

Public health management of cases

A BLC of ≥0.48µmol/L (or ≥10µg/dl) is the current threshold ('public health intervention level') for public health case management in England. HPTs will take steps to systematically identify and remove the potential source(s) of lead exposure in cases, following guidance in the PHE Lead Action Card [12]. This involves liaison and involvement with other PHE stakeholders, such as the Environmental Hazards and Emergencies department, and non-PHE stakeholders, such as the responsible clinician and local authority where the case resides. General information on lead and incident management (updated August 2019) can be found on the PHE website.

Purpose of this report

This report provides a summary of data extracted from the national LEICSS dataset for cases of child lead exposure in residents of England reported to Health Protection Teams during 1 January – 31 December 2018. As the number of cases in each year is small, we have compared the 2018 metrics to the previous 2015-2017 three-year average, where relevant, using data from cases with report dates between 1 January – 31 December for each of these years.

Figures are correct at the time of publication and may be subject to change as new information about cases becomes available.

This report and previous year's annual report and other surveillance reports are available at: https://www.gov.uk/government/publications/lead-exposure-in-children-surveillance-reports

Surveillance data indicators

Detection of cases of lead exposure in children in England, and support for timely case notification for public health action

Number of unique cases:

There were 45 unique cases detected in 2018. Seventy-six percent of cases were direct laboratory reports to LEICSS, slightly lower than the 2015-17 average of 79% (Table 1).

Table 1. Count and percentage of LEICSS cases, by reporting route to LEICSS, England 2018, and 2015-17

Route of detection by LEICSS	Count of cases 2018* (% of total)	Count of cases* 2015-17 (% of total)
Direct laboratory reports	34 (76)	91 (79)
HPZone search	11 (24)	24 (21)
Total	**45**	**115**

** Based on date case entered onto HPZone*

Timeliness of reporting of lab-detected cases to LEICSS and notification of Health Protection Teams

For the laboratory detected cases, the median delay between the date of specimen collection and the date the case was entered onto HPZone (as a proxy for date of report to HPTs) was 8 days, consistent with the 2015-17 median of 9 days (Table 2).

Table 2. Time between specimen collection and entry of case onto HPZone for case management for lab-detected LEICSS cases, England 2018, and 2015-17

Year	Cases	Cases with valid data*	Median days delay	LQ - UQ
2018	**34**	**31**	**8**	**6-13**
2015-17	**91**	**82**	**9**	**7-14**

* Cases where both a valid specimen date and a valid date of entry onto to HP Zone were extracted from HPZone; LQ – Lower Quartile, UQ – Upper Quartile

Occurrence and trends of cases of lead exposure in children

Count and detection rate (by LEICSS) of cases by PHE Centre and year

The number of cases detected in 2018 decreased slightly compared to 2017 (Table 3), although there is significant under-ascertainment of cases and therefore this should not be interpreted as a reduction in incidence.‡ The largest reduction in case detection was observed in the North West in 2018 (3 cases detected compared to 11 in 2017); case detection increased in the East and West Midlands, East of England and South West. The average detection rate for England between 2015 and 2018 was 3.76 cases per million children aged 0-15 years, although there was large regional variation; the detection rate was 11 times higher in Yorkshire and Humber (11.80 cases per million) compared to the North East (1.06 cases per million) (Table 3, Figure 1).

Variation in case detection over time and place is more likely to be due to differences in testing of children at risk and reporting by laboratories, rather than a change in the number of children exposed to lead hazards. Additionally, the total cases each year is relatively small, and is therefore prone to change due to random variation, meaning longer-term observation is required to confirm a trend.

‡ A note regarding detection rate

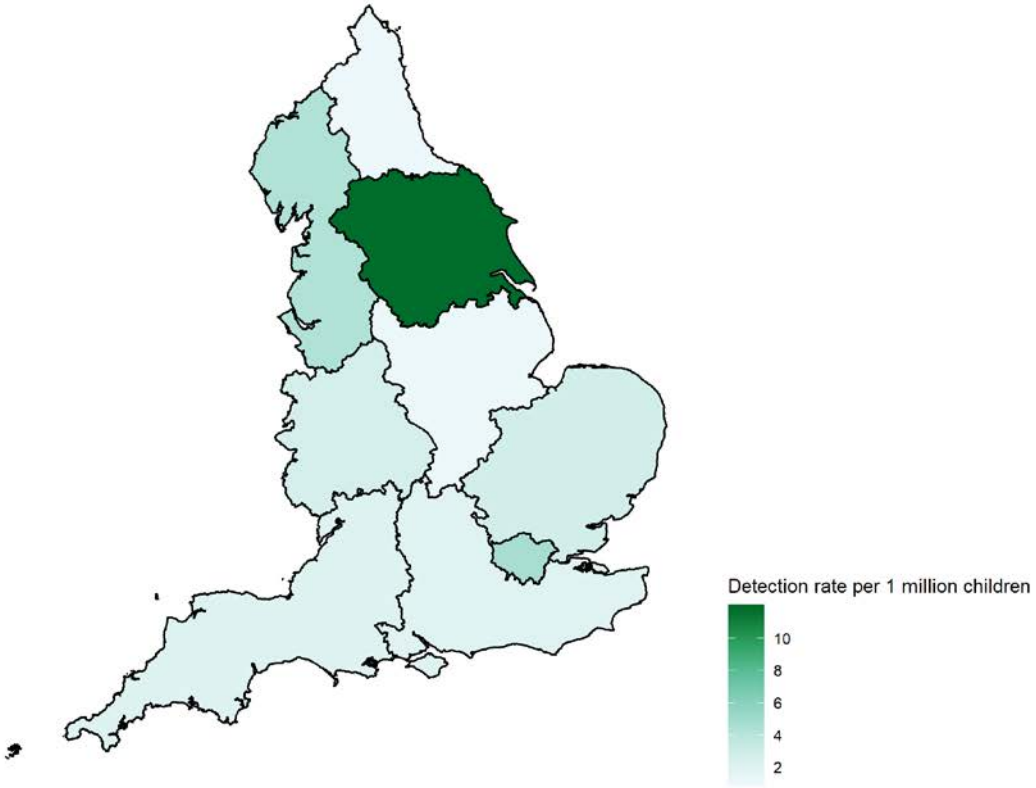
Because lead exposure below the level causing overt toxicity results in few or non-specific symptoms, surveillance of clinically reported cases is likely to under-ascertain the number of affected children. International population surveys, which more accurately estimate the number of children exposed to lead, suggest an expected incidence of cases of paediatric lead exposure higher than detected through LEICSS [7,8]. The figures reported here should not therefore be considered representative of the true incidence of child lead exposure in England. Various factors affecting case ascertainment are also likely to be driving the variation in regional detection rates. For instance, PHE is aware of a system introduced by Leeds SAS laboratory (based in Yorkshire and Humber) to actively prompt clinicians to consider testing for lead exposure in children whose blood is being tested for suspected iron deficiency, where that child is also known to have pica [13]. There is also active engagement of local clinicians by this laboratory. The 90% increase in testing and case reporting in this region following the introduction of this system demonstrates that differences in clinician awareness and testing rate strongly influence case ascertainment (potentially more so than differences in the frequency of lead hazards in the environment between regions). Testing of cases in laboratories not reporting cases to LEICSS may also explain part of the regional variation in case ascertainment, though SAS labs perform the large majority of BLC tests in children in England. Non-reporting of cases by participating laboratories may also have (more rarely) occurred. Irregular case entry onto HPZone may have prevented some cases being detected by our search, though cases first notified to LEICSS are entered using a standard procedure. Estimating area-specific testing rates would aid the interpretation of case detection rates but is difficult given the supra-regional catchment of SAS laboratories.

Table 3. Count and percentage of LEICSS cases, and average detection rate[†] of cases (per million 0-15 year old children) by PHE Centre and year of notification, England 2015-2018

Region	Cases 2015 (%)	Cases 2016 (%)	Cases 2017 (%)	Cases 2018 (%)	Cases 2015-18 (%)	Average detection rate[¥] of cases (per million per year) 2015-18
South East*	6 (18)	0 (0)	4 (8)	3 (7)	13 (8)	1.94
London*	5 (15)	7 (21)	10 (20)	12 (27)	34 (21)	4.69
South West	2 (6)	0 (0)	2 (4)	4 (9)	8 (5)	2.05
West Midlands*	2 (6)	3 (9)	3 (6)	4 (9)	12 (8)	2.61
East Midlands	1 (3)	0 (0)	0 (0)	3 (7)	4 (3)	1.13
North West	4 (12)	6 (18)	11 (22)	3 (7)	24 (15)	4.34
North East	1 (3)	0 (0)	1 (2)	0(0)	2 (1)	1.06
Yorkshire and the Humber*	9 (27)	12 (36)	16 (33)	12 (27)	49 (31)	11.80
East of England	3 (9)	5 (15)	2 (4)	4(9)	14(9)	2.8
ENGLAND	**33**	**33**	**49**	**45**	**160**	**3.76**

[†] Should not be interpreted as an estimate of incidence – see “Note regarding detection rate” page 10;
[¥] The numerator for this indicator is incident cases in 2015-18, and the denominator is the summed mid-year estimate of the 0-15 population for 2017 multiplied by 4. Cases allocated to PHE Centre according to postcode of residence;
* PHE Centres where a SAS laboratory that participates in the surveillance system is situated.

Figure 1 Average detection rate† of LEICSS cases (per million 0-15 year old children) by PHE Centre, England 2015-2018



† Should not be interpreted as an estimate of incidence – see “Note regarding detection rate” page 10.

Count and detection rate of cases by gender and age

The majority of cases in 2018 were male (64%), consistent with the 2015-2017 average (70%) (Table 4). Across all age groups the detection rate was higher in males than females (Figure 2). This gender disparity is also evident in some international survey findings [8], and may reflect a pre-disposition for males to behaviours or comorbidities that result in lead exposure (such as autism [14], itself associated with pica [15]), or a greater susceptibility to lead toxicity, and hence clinical presentation [16].

Table 4. Count and percentage of LEICSS cases by sex, England, 2018, and 2015-17

Sex	Count of cases 2018 (%)	Count of cases 2015-17 (%)
Female	14 (31)	31 (27)
Male	29 (64)	80 (70)
Unknown	2 (4)	4 (4)
Total	**45**	**115**

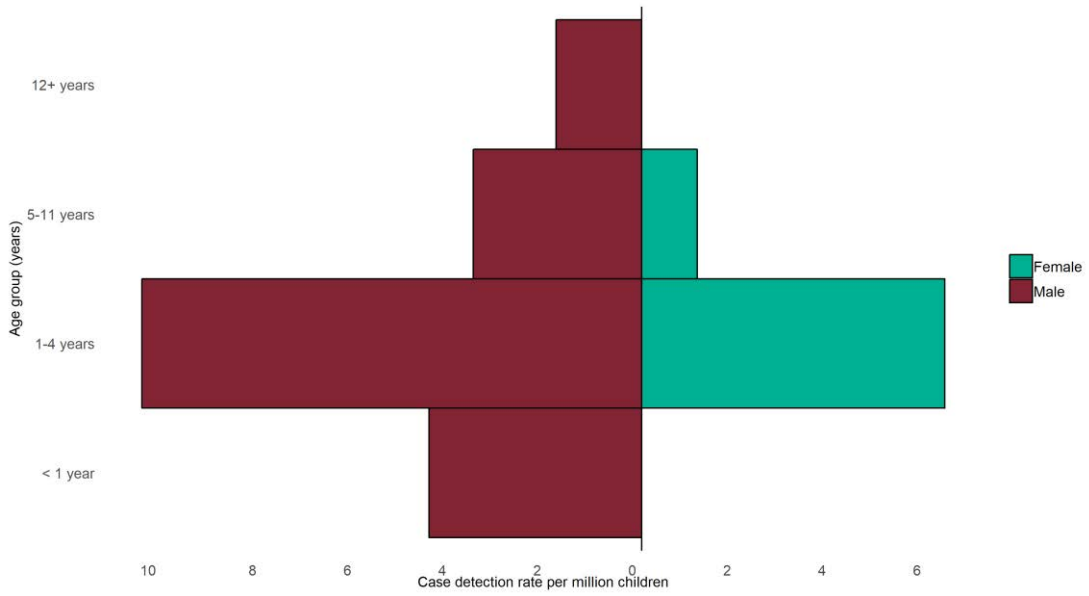
The highest case detection rate was in children aged 1-4 years in males and females (Figure 2); 60% of cases were aged 1-4 years in 2018, consistent with the 3-year average (56%) (Table 5). Approximately one third of cases in 2018 were aged 5-11 years, similar to the 2015-2017 average. There were few cases in the youngest and oldest age groups; no cases were detected aged under 1 year in 2018. The high percentage of cases in pre-school age children may reflect a greater vulnerability to lead exposure due to mouthing behaviours, as ingestion of lead containing substances (particularly from deteriorating paint) is likely to be the predominant route of exposure in children [2], and mouthing behaviour is common in this age group. Alternatively, children in this age group may be tested more frequently. For the adolescents, it is unknown what the common exposure sources are. They may be detected after exposure pathways other than pica are explored.

Table 5. Count and percentage of LEICSS cases by age group*, England, 2018, and 2015-2017

Age group	Count of cases 2018 (%)	Count of cases 2015-17 (%)
Under 1 year	0 (0)	3 (3)
1-4 years	27 (60)	64 (56)
5-11 years	14 (31)	43 (38)
12-15 years	4 (9)	5 (4)
Total	**45**	**115**

**Age at date of entry onto HPZone*

Figure 2. Average case age-gender* specific detection rate† per million 0-15 year old children per year, England 2015-2018 (n=154 cases with gender and age data)

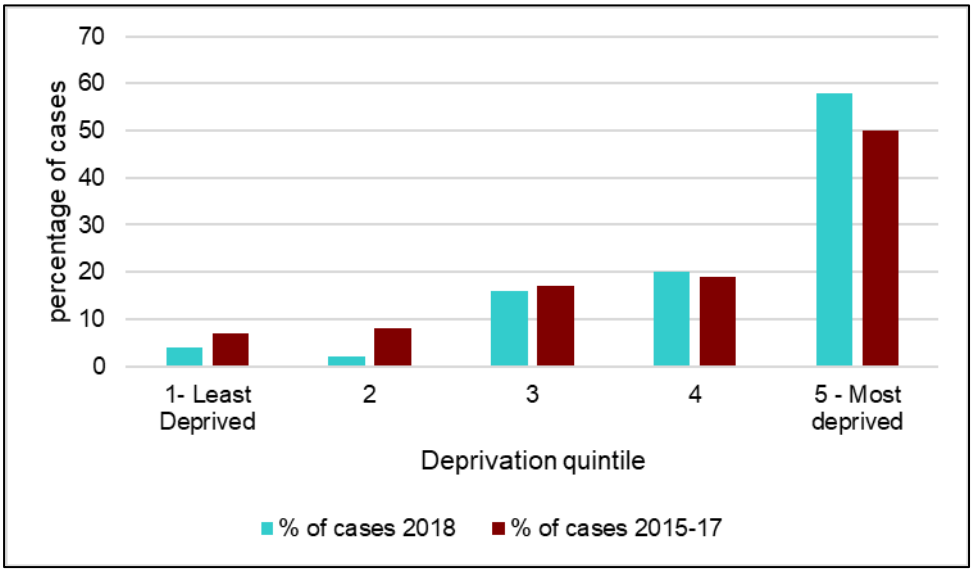


* Age at date of entry onto HPZone;
† The numerator for this indicator is the count of age-gender specific incident cases in 2015-18, and the denominator is the summed mid-year estimate of the age-gender specific 0-15 year old population for 2017 multiplied by 4.

Percentage of cases by quintile of index of multiple deprivation (IMD) status

IMD provides a measure of deprivation, evaluated across seven domains*, measured at the area-level. Seventy-eight percent of cases in 2018 lived in areas in the two most deprived quintiles of IMD, slightly higher than the previous three-year average (69%) (Figure 3); this is higher than expected given that 45% of the English population aged 0-15 years reside in areas failing within these two quintiles.** These observations are similar to patterns of lead exposure by socioeconomic status in US national survey data [8], and may reflect greater exposure to lead containing hazards, a higher frequency of co-morbidities (eg iron deficiency anaemia) or other factors pre-disposing to lead toxicity, and/or a greater tendency for clinician testing of children from deprived areas.

Figure 3 Percentage of LEICSS cases in each quintile of index of multiple deprivation¥, England 2018 and 2015-17.



¥ Index of multiple deprivation (IMD) assigned to the Lower-level Super Output Area of the cases' residential postcode, using IMD scores from 2015

* See: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

** Calculated using ONS mid-year estimate populations for England, assigned to deciles of IMD 2015: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/006518deathsandpopulationsbyindexofmultipledeprivationimddecileenglandandwales2001to2015.

Blood lead concentrations of laboratory-detected cases

The median blood lead concentration (BLC) in 2018 was 0.82 µmol/L(16.98 µg/dL), similar to the 2015-17 median (0.78 µmol/L(16.15 µg/dL)) (Table 7). Ninety-two percent (data not shown) of blood lead concentrations were <1.93µmol/L(<40 µg/dL) in 2015-2018, a concentration most consistent with either being asymptomatic, or with non-specific neuro-behavioural clinical manifestations [1], indicating these children were detected based on high index of clinical suspicion.

Table 7. Blood lead concentration (µmol/L) of laboratory-detected LEICSS cases, England, 2018, 2015-2017

Year	Cases with data/total cases	Min.*	Max.	Median	Lower Quartile	Upper Quartile	Mean
2018	34/34	0.5	2.81	0.82	0.59	1.17	0.97
2015-17	95/95**	0.48	17.59	0.78	0.55	1.09	1.13

* Only children with a BLC≥0.48µmol/L were eligible for notification to LEICSS
** Includes four HPZone-detected cases subsequently reported to LEICSS by participating laboratories with blood lead specimen dates prior to/on the same day as date of report to PHE HPTs.

Children whose death was attributed to lead exposure

This information is taken from data extracted from the PHE HPZone case management system to the LEICSS dataset. Only deaths attributed partly or wholly to lead exposure are shown, and only in cases that meet the LEICSS case definitions. Case information was also corroborated with the investigating HPT. In the period of 2015-2018, PHE HPTs recorded 1 death in a child in England partly or wholly attributed to lead exposure.

A case report has since been published, showing the death occurred in a two-year-old boy with pica and iron deficiency who had ingested lead-containing paint, resulting in acute lead toxicity [13]. Lack of clinician awareness of the association between pica and lead exposure was cited as a root cause of the delayed diagnosis and subsequent death of the child [13]. Previous research has shown deaths from lead exposure in children to be very infrequent in England [17].

Duration of case investigation

Of the cases where the investigation had been concluded by the time of data extraction for this report (January 2019), the median duration of the investigation was 10 weeks, three weeks shorter than the median for 2015-2017. This lower duration may be because more 2018 cases were still open (eg under investigation) at the time of data extraction, and this may include those with longer duration of investigation.

Table 9. Duration, in weeks, of the public health investigation of LEICSS cases* reported to the surveillance system, England, 2018, 2015-17

Year	Closed Cases/Total cases	Median duration (weeks) (LQ-UQ)
2015-17	102/115	13 (5-23)
2018	37/45	10 (4-20)

* Period between date entered onto HP Zone and date case closed on HPZone; cases must have been closed at date of data extraction from HPZone in January 2019; LQ – Lower Quartile; UQ – Upper Quartile.

System developments

Public health intervention level for lead (and laboratory reporting level)

The public health intervention level for lead has been lowered over time to reflect both the gradual decline in population exposure, and the changing knowledge that lead exposure in children is associated with toxicity at very low blood concentrations. We now know that lead exposure is associated with neuro-behavioural impairments at blood concentrations of 0.24µmol/L (5µg/dl) and even lower [1,18]. Lowering the intervention level for lead would follow international precedent set by recommendations in the USA [19], Australia [20], Germany [21], France [22] and Wales [23], and would offer benefits of case management to more affected children and communities.

An evaluation conducted by PHE in 2018 recommended that the public health intervention level for lead be lowered from ≥10µg/dL (≥0.48µmol/L) to ≥5µg/dL (≥0.24µmol/L) and should apply to children aged up to and including 15 years, and to pregnant women.

This recommendation is based on estimates in pre-school children who have the highest BLCs, to maximise the specificity to detect children most likely to benefit from public health action. The evaluation concluded that lowering the intervention level for lead to ≥5µg/dL (≥0.24µmol/L) would identify children with a BLC in the top 2% of the population range and would have a net positive impact on health inequalities. It is estimated that lowering the intervention level for lead to ≥5µg/dL (≥0.24µmol/L) would result in a two to three-fold increase in case notification to PHE in the short- to medium- term (provided that there is no change in other factors influencing case notification); this should represent only a small absolute increase in the number of notifications to a single HPT. A working group has been set up to coordinate communication of the new intervention level to stakeholders and update the lead action card and LEICSS documentation. It is estimated that the new public health intervention level for lead will apply in 2020. An intervention level for lead of ≥10µg/dL (≥0.48µmol/L) for non-pregnant adults will remain.

Invitation of further laboratories to participate in surveillance

We wrote to laboratories in the UK National External Quality Assessment Scheme for Trace Elements (which includes measurement of blood lead concentration) to invite them to participate in case reporting to LEICSS in October 2018; six new laboratories have agreed to participate (Bristol Southmead, Alder Hey, Royal Liverpool, Northern General (Sheffield), Birmingham Heartlands and the private Doctors Laboratory (London)). Other UKAS accredited laboratories testing for child BLC are also welcome to participate.

Governance and procedures

Following implementation of a permanent surveillance system in 2016 and in accordance with the governance framework for other PHE surveillance systems, a data sharing agreement was introduced with participating laboratories and a new case notification form in 2018. New procedures were also introduced to enter laboratory data onto HPZone and extract it for analysis which reduced the requirement to maintain a separate laboratory dataset. Standard Operating Procedures for the surveillance were also drafted and updated.

Alerts for testing for blood lead

Introduction of an alert on the electronic test request system by Leeds SAS laboratory to encourage clinicians to consider testing for blood lead (for those children suspected of pica/iron deficiency) increased test requests by 90% since 2017. We will work with other laboratories to explore the feasibility of implementation of a similar model across the SAS laboratory network.

Exposure assessment

Information on exposures in children with elevated BLC is currently captured through a questionnaire completed by HPTs on paper or as an electronic document which is uploaded to HPZone. This questionnaire will be converted into an online survey format to help HPTs explore and scope exposure information and collect relevant information for surveillance. A project is also currently underway to update a retrospective survey of potential exposures [11] and public health management for cases to incorporate data on cases up to the end of 2018.

PHE's Environmental Public Health Surveillance System

The Environmental Public Health Surveillance System (EPHSS) collates and integrates data from selected databases on environmental hazard, exposures and health outcome data; further details are provided on the PHE website. Development of a lead exposure in children module is underway to make LEICSS data available to users. Currently this is available to PHE staff, but will eventually be accessible to external users. For access please email ephss@phe.gov.uk

LEICSS outputs

The following outputs have been produced in relation to LEICSS and its precursors between 2014 and 2019.

Publications

Roberts DJ, Crabbe H, Owodunni T, Gordon-Brown H, Close R, Reshat S, Sampson B, Ruggles R, Dabrera G, Busby A, Leonardi G (2019). Case epidemiology from the first three years of a pilot laboratory-based surveillance system for elevated blood lead concentrations among children in England, 2014-17: implications for public health action and surveillance. Journal of Public Health doi.org/10.1093/pubmed/fdz024.

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July 2018, Thomas E, Close R, Ruggles R (July 2018). Surveillance of Elevated Blood Lead in Children (SLiC) – a British Paediatric Surveillance Unit analysis.

Crabbe H, Dabrera G, Close R, Morris J, Keshishian C, Leonardi G, Ruggles R. (2016). Lead poisoning in children; evaluation of a pilot surveillance system in England, 2014-15. In: Abstracts of the 2016 International Society of Environmental

Epidemiology (ISEE): abstract P2-267; ID: 3829. Environmental Health Perspectives.

PHE (September 2016). Evaluation of the Pilot Laboratory Based Surveillance of Lead Poisoning in Children in England, 2014-2015. Crabbe H, Ruggles R, Dabrera G, Close R, Morris J, Leonardi G (PHE Report).

Dabrera G, Sampson B, Ruggles R, Leonardi G (2015). Investigating lead poisoning in children – could surveillance help? *QJM: An International Journal of Medicine* **108**(11): 849.

Presentations

Hodgson S, Wei G, Crabbe H, Roberts D, Leonardi G, Busby A**.** Creating a lead hazard map to support public health action in England**,** PHE Research and Science Conference, University of Warwick, 20-21 March 2018.

Roberts D, Crabbe H, Busby A, Reshat S, Owodunni T, Gordon-Brown T, et al**.** Case epidemiology from the first 3 years of laboratory-based surveillance of children with elevated blood-lead concentrations in England, 2014-17. PHE Research and Science Conference, University of Warwick, 20-21 March 2018.

Roberts D**.** Development of an Environmental Public Health Surveillance System: surveillance of lead poisoning in children**.** National Poisons Information Service CPD event, Cardiff, March 2017.

Roberts DJ, Crabbe H, Leonardi G, Close R , Owodunni T, Reshat S, Busby A. Lead poisoning in children; overcoming challenges to develop a surveillance system for case management and population health. PHE Public Health Research and Science Conference, University of Warwick, March 2017.

Crabbe H, Dabrera G, Close R, Morris J, Keshishian C, Leonardi G, Ruggles R. Lead poisoning in children; evaluation of a pilot surveillance system in England, 2014-15. International Society of Environmental Epidemiology (ISEE) conference, Rome, August 2016.

Crabbe H. Lead poisoning in children; evaluation of a pilot surveillance system in England, 2014-15. US CDC Summit: ‘CHARTing the Course’. Atlanta, January 2016.

Current and future research and projects

These include:

- the SAS laboratory network have requested further guidance on repeat testing of BLC in children who are already under investigation for elevated lead levels. We will work with CRCE and NPIS to consider development of additional guidance
- the Environmental Epidemiology Group at CRCE are working on producing hazard maps for soil lead concentration, housing age and index of multiple deprivation to develop a lead exposure model
- the LEICSS working group will work with The British Paediatric Surveillance Unit and Royal College of Paediatrics and Child Health to deliver a webinar on lead as part of their series on rare diseases to raise awareness amongst clinicians
- the PHE Lowering the Lead Intervention Level for Lead working group has reviewed the resources and guidance required to lower the intervention level for lead and are working with stakeholders to ensure implementation of the new intervention level for lead
- the lead exposure questionnaire in use by HPTs to support initial case management has been reviewed and updated to better scope and capture potential exposures in cases reported to PHE
- the LEICSS team are developing some case studies for the SAS labs to use in education and training
- the LEICSS steering group is widening the group of stakeholders who are consulate/communicated with on a regular basis

Implementation of recommendations since publication of the annual report for 2017

The following recommendations made in 2018 have been actioned (with current progress noted in italics).

For the LEICSS steering and working group

Introduce a new case notification form and data sharing agreement with laboratories, and new procedures to record laboratory data directly into HPZone and extract it for analysis. These measures should improve laboratory data recording quality. *Case notification forms were updated. Data sharing agreements have been signed with most laboratories. SOPs for recording and extracting data have been written and put in place.*

Introduce methods to extract and collate information from the detailed exposure questionnaires conducted on lead exposure cases by investigating HPTs, in order to collect and analyse data on other potentially important case factors. *A new online questionnaire has been developed to help HPTs explore potential exposures and to capture exposure information. We plan to undertake a look-back exercise to explore exposure sources in cases captured by the system so far*.

Survey participating laboratories as to whether they offer laboratory-based systems to prompt clinicians to test for lead exposure in children, or undertake awareness raising activities in their area, for example as implemented in Leeds SAS laboratory [13]. *We have worked with the SAS Lab network to identify best practice and support the roll out of alerting systems that are planned*.

Monitor the developing evidence on laboratory-based systems to prompt testing of children at high risk of lead exposure, for example as implemented in Leeds SAS laboratory [13]. *As previous point, we support best practice and will monitor the impact of changes to laboratory based systems*.

Continue to encourage further laboratories to participate in the surveillance system. *We wrote to laboratories in the UK National External Quality Assessment Scheme for Trace Elements (which includes measurement of blood lead concentration) to invite them to participate in case reporting to LEICSS in October 2018; six new laboratories have agreed to participate and are now reporting into the surveillance system*.

Consider the evidence and arguments for lowering the public health intervention level for lead and laboratory reporting BLC to ≥0.24µmol/L (5µg/dl). *A PHE working group was formed in 2018 and reviewed the evidence for lowering the intervention level for lead. Proposals to lower the intervention level are in place and stakeholder consultation and communication is being conducted*.

Share the findings of this report with the Royal College of Paediatrics and Child Health, and Royal College of General Practitioners to raise awareness amongst paediatricians and GPs. *The report was sent to these stakeholders and further communication with the RCPCH is taking place*.

Develop a broader group of consulting stakeholders including clinical and lay (parent and guardian) representatives. *A stakeholder mapping exercise was conducted and new stakeholders were identified. A consultation and distribution list is continuously updated and used to communicate about lead exposures*.

Recommendations from the annual report for 2018

For the LEICSS steering and working group

These groups should:

- work with the SAS laboratory network to explore implementation of an alert on the electronic test request system to prompt clinicians to consider blood lead testing based on the model introduced at Leeds SAS laboratory [13]
- continue to encourage further laboratories to participate in the surveillance system
- audit the procedure for managing lead exposure laboratory reports to monitor and maintain data quality
- develop methods to calculate and describe rates of BLC testing by time, place and person
- share the findings of this report with the Royal College of Paediatrics and Child Health, and Royal College of General Practitioners to raise awareness amongst paediatricians and GPs
- make recommendations to support a survey into the current prevalence of elevated blood lead levels in children in England
- support PHE to establish a dedicated lead poisoning prevention information service including web site material and public information leaflets for surgeries and DIY stores, etc

For laboratories

- participating laboratories should always notify cases to LEICSS by emailing the case notification form to phe.leicss@nhs.net
- laboratories interested in participating in the surveillance system should also email phe.leicss@nhs.net to express their interest
- participating laboratories should be aware that PHE will advise when the new lower public health intervention level for lead of ≥5µg/dL (≥0.24µmol/L) for children under 16 years and pregnant women will apply and when to notify cases at the lower level.

For PHE Health Protection Teams

HPTs should:

- be aware that there is likely a large regional variation in clinician awareness, testing and reporting practice for lead exposure in children
- determine which laboratories test for lead exposure in children in their population, and whether the laboratory participates in lead surveillance reporting
- share this report with local paediatricians and GPs to raise awareness of sources of lead exposure, children at most risk, and presenting symptoms/signs of exposure (see box below)
- be aware that the public health intervention level for lead will be lowered from ≥10µg/dL (≥0.48µmol/L) to ≥5µg/dL (≥0.24µmol/L); a briefing note will be issued to communicate when this change will be implemented.
- encourage clinicians to notify them of children with BLC at or above the public health intervention level for lead

For clinicians

Clinicians should:

- be aware of the most important sources of lead exposure in children (see box, below)
- be aware of the children at most risk of lead exposure (see box, below), and have a low threshold for screening these children for lead exposure if they may have been exposed to lead hazards
- educate parents/guardians of children at risk about prevention of lead exposure, through the provision of information leaflets etc.
- consider lead exposure as a potential diagnosis in children presenting with symptoms/signs of acute or chronic lead exposure (see box, below)
- be aware of PHE's role in managing cases, how to report a case, and of the case management and surveillance benefits of reporting cases to PHE
- Refer to the Other Resources section, below, for details of how to report a case of lead exposure, and for resources offering further guidance on case management

Box 1. Sources of lead exposure in children, children at most risk of exposure, and presentations of lead exposure in children

Important sources of lead exposure in children:

- deteriorating leaded paint (particularly houses built prior to early 1970s)
- consumer products (if unregulated): medicines, ceramic cookware, toys
- parental hobbies or occupations (including dust on clothing)
- lead water pipes, and lead from drinking water pipe fittings (i.e. solder) (particularly houses built prior to early 1970s)
- contaminated soil/land

Children at most risk of lead exposure:

- children with pica or increased hand to mouth behaviour (eg children with autism or global developmental delay), particularly with iron deficiency
- children who have recently migrated from countries with less regulation to prevent lead exposure
- children living in older homes and attending older schools containing leaded paint

Presentations of lead exposure in children:

- acute exposure resulting in high BLC: anorexia, abdominal pain, constipation, irritability and reduced concentration, encephalopathy
- chronic exposure [24]:
  lower BLCs - mild cognitive and behavioural impairments, may contribute to global developmental delay, decreased academic achievement, IQ, and specific cognitive measures (S); increased incidence of attention-related behaviours and problem behaviours (S), and delayed puberty and decreased kidney function in children ≥12 years of age (L);
  higher BLCs - reduced appetite, abdominal pain, constipation, anaemia, delayed puberty, reduced postnatal growth, decreased IQ, and decreased hearing (S); and increased hypersensitivity/allergy by skin prick test to allergens and increased IgE (L).

Where (S) = sufficient evidence and (L) = limited evidence

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Other resources

Further PHE resources for the public health management of cases of lead exposure:

- lead pages in the PHE chemicals compendium https://www.gov.uk/government/publications/lead-properties-incident-management-and-toxicology
- Lead Action Card (PHE login required) http://phenet.phe.gov.uk/Resources/duty-doctors/Environmental-hazards/Chemical%20resources/Lead-action-card-chronic-exposures.pdf

Resources for clinicians:

- clinicians with clinical lead exposure queries should consult TOXBASE or call the National Poisons Information Service, see https://www.toxbase.org/

Contacts:

- to notify cases (participating labs only): phe.leicss@nhs.net
- general enquiries: epht@phe.gov.uk
- lead surveillance module in PHE's Environmental Public Health Surveillance System: ephss@phe.gov.uk
- to notify cases (direct to a Health Protection Team) find the relevant Health Protection Team using the residential postcode of the case: https://www.gov.uk/health-protection-team

Steering and working group members

Steering group

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Acknowledgement to laboratories

Supra-regional Assay Services Trace Elements laboratories:

- Birmingham
- Leeds
- Southampton
- Guildford
- London Charing Cross
- London Kings College

Other laboratories notifying cases included in this report:

- The Doctors' Laboratory, London
- Cardiff Toxicology Laboratories
- Southmead Hospital, Bristol
- Alder Hey Children's Hospital, Liverpool

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About Health Protection Report

Health Protection Report is a national public health bulletin for England and Wales, published by Public Health England. It is PHE's principal channel for the dissemination of laboratory data relating to pathogens and infections/communicable diseases of public health significance and of reports on outbreaks, incidents and ongoing investigations.

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