

Lead Report 2016: Broken Hill children less than 5 years old

Revised (2016 Census)



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Table of Contents

Executive Summary	4
Introduction	5
Population Profile	7
Methods	8
Collection of Blood Samples.....	8
Reporting of Blood Lead Levels.....	8
Age-sex Standardisation of Results	8
Notifiable Blood Lead Levels.....	8
Participation Rates	9
Results	9
Screening of Newborns	9
Screening of Children Aged 1-4 years.....	10
Screening of Aboriginal Children Aged 1 to 4 years	17
Estimate of Participation Rate.....	20
Conclusion	21
Appendix 1	22
References	22

Executive Summary

The information contained in the 2016 Lead report provides an update on the ongoing public health issue of elevated blood lead levels in children under the age of 5 in Broken Hill.

All children under the age of 5 residing in Broken Hill have been offered blood lead testing since 1991. This testing is voluntary and offered through the Broken Hill Child and Family Health Service and Maari Ma Primary Health Care Service. In addition, screening of umbilical cord blood lead levels of newborns, born in Broken Hill to resident mothers, commenced in 1996.

In April 2016 the NSW Ministry of Health endorsed the revised National Health and Medical Research Council (NHMRC) guidelines for the notification of blood lead levels from 10 µg/dL to 5 µg/dL. This report uses the revised lead blood notification figure and therefore reports on the proportion of children with blood lead levels under 5 µg/dL.

In 2016 there was a small increase in the total number of children screened (679 to 687). During this period there was a 16% increase in the number of Aboriginal children screened (178 to 207). This contrasts to a 4% decrease in the number of non-Aboriginal children screened (501 to 480). The 207 Aboriginal children screened in 2016, represents the highest number screened on record.

The geometric lead mean level (age-sex standardised) for all children (1 to 4 years) increased slightly from 5.8 µg/dL in 2015 to 5.9 µg/dL in 2016. The mean result for Aboriginal children improved significantly in this period, with a decrease in blood lead levels from 9.3 in 2015 to 7.6 µg/dL in 2016. However, this was not the case for non-Aboriginal children where there was an increase in blood lead levels, from 4.9 in 2015 to 5.2 µg/dL in 2016. Therefore, the gap between these results was reduced between Aboriginal and non-Aboriginal children in 2016 – to 2.4 µg/dL – nearly half the gap recorded in 2015.

While the gap in the geometric lead level mean between non-Aboriginal and Aboriginal children reduced between 2015 and 2016, the gap is more than double for the proportion with blood lead levels below 5 µg/dL. The 2016 results show 50% of non-Aboriginal children in Broken Hill had a blood lead level below 5 µg/dL, compared to only 22% of Aboriginal children. However, the result for Aboriginal children has improved between 2015 and 2016 (17% to 22%), whilst the result for non-Aboriginal children decreased in that same period from 54% to 50%. When combining the results for Aboriginal and non-Aboriginal children, the result was stable (43% to 42% of all children with blood lead levels below 5 µg/dL between 2015 and 2016). In relation to the previous NHMRC notifiable blood lead level of 10 µg/dL there has been an improvement in results between 2015 and 2016 with an increase in the proportion of all children with a blood lead level below 10 µg/dL, 76% and 80% respectively.

There remains ongoing work to reduce blood lead levels in Broken Hill. Although there has been improvements in Aboriginal children results in 2016, the proportion of Aboriginal children in all lead level categories above 5 µg/dL are higher compared with non-Aboriginal children. Furthermore, 58% of all children (1-4 years) tested in Broken Hill have blood lead levels above the current NHMRC notifiable level (5.0 µg/dL). In addition there has been an increase in the geometric mean lead level for non-Aboriginal children in 2016 and decreases over time to the proportion of all children (1-4 years) tested with lead levels below 5 µg/dL.

Introduction

Broken Hill is a historical town founded in 1883 on mining of the 'line of lode,' the world's largest and richest silver-lead-zinc mineral deposit. Since the Broken Hill Proprietary Company Limited was established in 1885, lead poisoning had been evident among early miners and their families. Despite this evidence, lead poisoning was seen mainly as an occupational rather than population health issue.

Since 1991, parents/carers in Broken Hill have been offered voluntary blood lead screening for children under the age of 5 years old. The combination of; a reminder letter, lead testing aligned with the immunisation schedule, promotions and advertising in the local media, are used to encourage lead screening. From 1996, newborn umbilical cord blood has been tested to determine the impact of lead transfer from the mother to the child.

According to the World Health Organisation, blood lead levels around 10.0 µg/dL are now known to cause damage to the developing brain and nervous system of children. In addition, the immune, reproductive and cardiovascular systems are also adversely affected¹.

Ingestion of lead is the most common exposure pathway for children. The combination of a child's innate curiosity and hand-to-mouth behaviour results in bringing lead-containing or lead-coated objects (eg contaminated soil or dust, peeling lead based paint) to their mouth. Exposure pathways also include from a mother to a foetus; inhalation of lead containing dust and less commonly absorbed through the skin. Compounding the issue in young children is that they absorb 4 to 5 times as much ingested lead compared to an adult from a given source. Undernourished children are also more susceptible to lead because their bodies absorb more lead if other nutrients, such as calcium, are lacking¹.

The Broken Hill Lead Reference Group, founded in 2008, is a multi-agency group led by the Broken Hill City Council. It consists of community interest groups, mining companies and government agencies representing and advocating for the Broken Hill community regarding lead. The Broken Hill Lead Steering Committee, also founded in 2008, was constituted to focus on the health issues related to elevated blood lead levels in children. Both groups have an interest in minimising the impact of lead exposure whilst maintaining a viable mining industry in Broken Hill.

Since 1993 blood lead notification levels have been 10 µg/dL, however, in May 2015, the NHMRC completed an evidence review and issued a statement for a revised blood lead notification level of 5 µg/dL². The evidence review found an association between levels less than 10 µg/dL and health effects. The effects include: reduced Intelligence Quotient and academic achievement in children; behavioural problems in children; a delay in sexual maturation in adolescents and increased blood pressure in adults². As of April 2016, NSW Health adjusted the notifiable blood level to 5 µg/dL. As a result, less than 5 µg/dL has been used as the benchmark level for this report.

From July 2015, following significant planning and advocacy, the NSW Government funded the Broken Hill Environmental Lead Program (BHELP) with \$13 million, over 5 years. Five people have

¹ World Health Organisation, Childhood Lead Poisoning, 2010

² National Health & Medical Research Council (NHMRC), Evidence on the Effects of Lead on Human Health, May 2015

been recruited to the BHELP program under the auspices of the Environmental Protection Agency (EPA). The Broken Hill Environmental Lead Program Steering Committee is made up of representatives from EPA, Far West LHD, Broken Hill Lead Reference Group and two Aboriginal representatives.

Future challenges for managing blood lead levels in Broken Hill children that are above the new guidelines include:

- ensuring that all children continue to be screened and that screening data is collected and reported for all children, including Aboriginal children;
- ensuring the community continues to engage in lead remediation activities;
- ensuring that active research into effectiveness of strategies employed continues to direct the way the program is run, and
- maintaining long term momentum in the community to support childhood screening in the first five years of life once the NSW Government funded Broken Hill Environmental Lead Program finishes in 2020.

Population Profile

Each Census conducted since lead monitoring began (1991, 1996, 2001, 2006, 2011 and 2016) has seen a decreasing trend in both the number and proportion of children under the age of 5 years residing in the Broken Hill Local Government Area (Table 1). The graph in Figure 1 represents the Estimated Resident Population (ERP) (an annual population figure calculated by the Australian Bureau of Statistics) for 0-4 year olds in Broken Hill (1972 to 2015) by gender.

Analysis conducted for the annual lead report is stratified by Aboriginality to monitor any inequitable burden of high blood lead levels which may exist. Counts of Aboriginal children population are sourced from the Census and are reliant on self-identification. Unlike the total population of under 5 year olds, the number of Aboriginal children has increased from 1996 to 2016 and is projected to continue increasing (Table 1), in addition to the proportion.

Table 1. Demographic profile of children under 5 years of age in Broken Hill

	1996	2001	2006	2011	2016
Total 0-4 years	1,427	1,255	1,191	1,070	974
Aboriginal children 0-4 years (% of Aboriginal children)	112 (8%)	165 (13%)	177 (17%)	176 (16%)	182 (19%)

Source: Australian Bureau of Statistics (ABS) Census data.

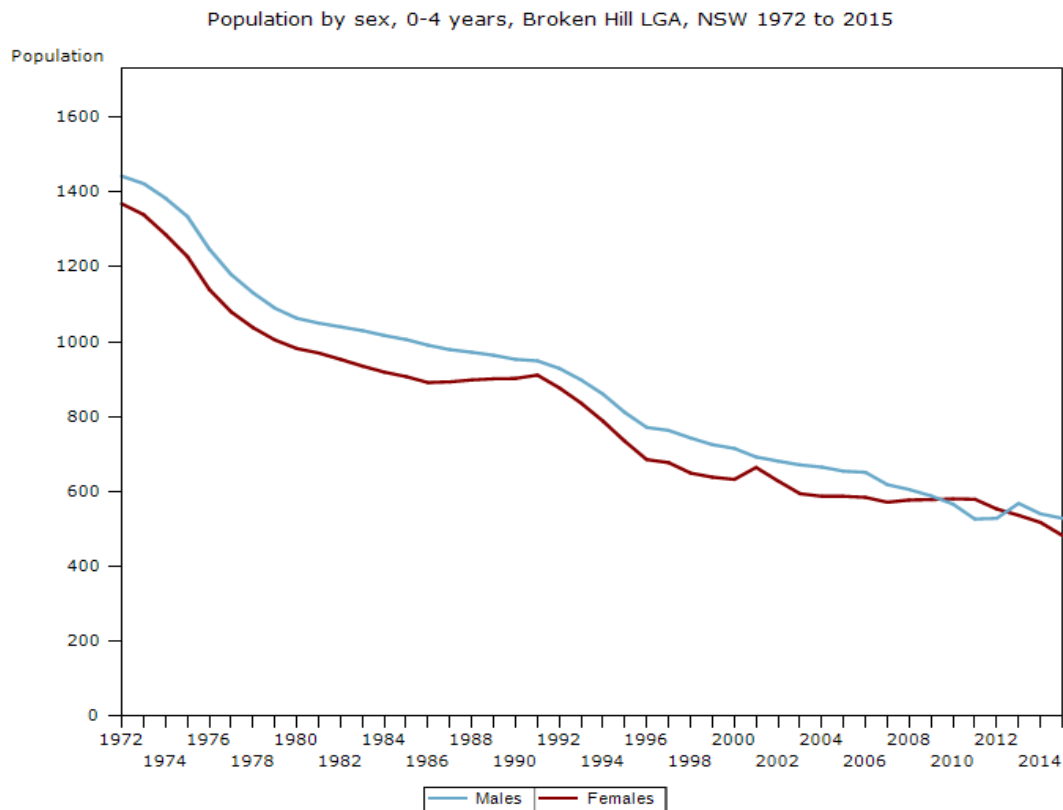


Figure 1. Estimated Resident Population by gender, 0-4 years, Broken Hill, 1972-2015

Source: NSW Ministry of Health, NSW Health Statistics (<http://www.healthstats.nsw.gov.au>)

Methods

Collection of Blood Samples

For newborn babies, umbilical cord bloods are laboratory tested in the same way as a venous sample. Blood lead levels for children less than 5 years are taken as either a finger prick (capillary) or venous test. Since October 2008 parents have had the option of having their children screened with a less invasive capillary sampling (finger prick) method. If a child has received both a venous and a capillary test throughout the year, the measurement from the venous test is used. This is because a venous test, though a more invasive procedure than a finger prick, provides a more accurate measure of blood lead levels.

With lead screening aligned with immunisation, testing may occur over the immunisation schedule (12 months, 18 months, 2 years and 4 years of age). Therefore, a child may present at 12 months and 18 months or 18 months and 2 years in the same calendar year. Only the first (younger age) test is used and this is the main reason why there are more children's first tests in the first 6 months of a year. This also explains the success in capturing those aged between 12 months and less than 3 years.

Reporting of Blood Lead Levels

For analysis and reporting purposes, only a child's first test in the calendar year is used for calculations, to ensure only one result per child is used per year.

The geometric mean (instead of an arithmetic mean or average) is used to report blood lead levels throughout this report. A geometric mean is calculated by taking the n th root of the product of n numbers. Blood lead levels in an affected location may have the majority of levels in the lower range, however will also have some results which are significantly higher (e.g. 5 to 10 times higher). The geometric mean normalises the ranges being averaged so that no range dominates the weighting.

Age-sex Standardisation of Results

Because children's blood lead levels vary by age and gender, it is difficult to compare blood lead levels from one year to another unless the same proportion of children in each age group is tested in successive years. Therefore age-sex standardisation is used to account for this change. Effectively, this determines what the blood lead level would be if all children in Broken Hill were tested by applying the proportion of children to each age-sex group from the most recent Census (i.e. 2016). This age-sex adjusted population mean is the one reported over time for children aged 1-4 years (Figures 3 & 4).

Notifiable Blood Lead Levels

The 5 µg/dL notification level was implemented in February 2016 by NSW Ministry of Health. Throughout this report, less than 5 µg/dL has been used as the benchmark level to enable insight into the extent of lead as an issue for children in Broken Hill – in line with NHMRC and NSW Health guidelines.

Participation Rates

Population results by single ages (e.g. 0, 1, 2, 3...) are only available for Census years. Therefore, for Census years there is a count of (1, 2, 3 and 4 year olds) to determine a participation rate. Figure 9 demonstrates the participation rates from 2008 to 2016, with 2011 and 2016 being Census years. For non-Census years, the ABS Estimated Resident Population (ERP) for the 0 to 4 years group, minus the number of births, is used to calculate participation rates for 1 to 4 year olds. There is significant under reporting of Aboriginality in the Census and therefore calculating Aboriginal participation rates is unreliable.

Results

Screening of Newborns

Once lead has entered the blood stream, it is stored in bone. For an affected pregnant woman, lead is released from the bones and into the blood and becomes a source of exposure to the developing foetus. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations³.

In 1996, umbilical cord blood screening commenced in Broken Hill, to determine lead levels in children at birth. To test the lead levels in newborns, a sample of venous blood from the umbilical cord is used. For Broken Hill expectant mothers to birth at the Broken Hill Hospital, they must be considered low risk. If the pregnancy is rated as higher risk, expectant mothers are referred to Flinders Medical Centre or Women's and Children's Hospital (both in Adelaide). Details of the criteria for higher risk births are contained in Appendix 1 and include, for example, a Body Mass Index of > 45 at 36 weeks gestation and high risk co-morbidities. Not all births referred to South Australia will have their cord bloods tested unless the mother has requested that results be sent back to Broken Hill.

Historically, from commencement in 1996 there has been a steady decline in umbilical cord blood lead levels, from 2.9 µg/dL in 1996 down to 1.2 µg/dL in 2008. Since 2008, cord blood lead levels have remained relatively stable.

The 2016 umbilical cord lead level geometric mean is 0.84 µg/dL (Figure 2). Although this appears like a significant improvement to all previous years, it can't be accurately compared to prior years. From 26th April 2016, there was an improvement in recording blood cord levels, through the inclusion of decimal points, resulting in greater accuracy. The first full year of cord blood lead levels with increased accuracy will be 2017.

In 2016, there were a total of 231 births in Broken Hill, out of these 208 babies were born to mothers who were resident of Broken Hill. This marks a slight increase in births from previous years (220 in 2015) which coincides with the introduction of the Broken Hill Midwifery Program from mid-July 2016. It is hoped that this program will allow for more women to safely deliver in Broken Hill, therefore increasing the number of available cord bloods to be tested in Broken Hill in the coming years. In 2016, a total of 192 umbilical cord blood samples were taken to conduct lead level testing – representing

³ World Health Organisation, Childhood Lead Poisoning, 2010

92% of the babies born to local mothers. The variance from 100% of all babies born at Broken Hill being tested is due to a requirement for a consent form to be signed by the mother to conduct the cord test. There were 165 full records of cord lead results for newborns in 2016. This difference in the total collected for testing (192) and the total of records with results (165) is that some test results are removed and excluded from analysis, namely: records of babies born to mothers living on a property and not within the town of Broken Hill, and records identified with recording issues.

Umbilical Cord Blood Lead Screening in Broken Hill newborns 1996-2016

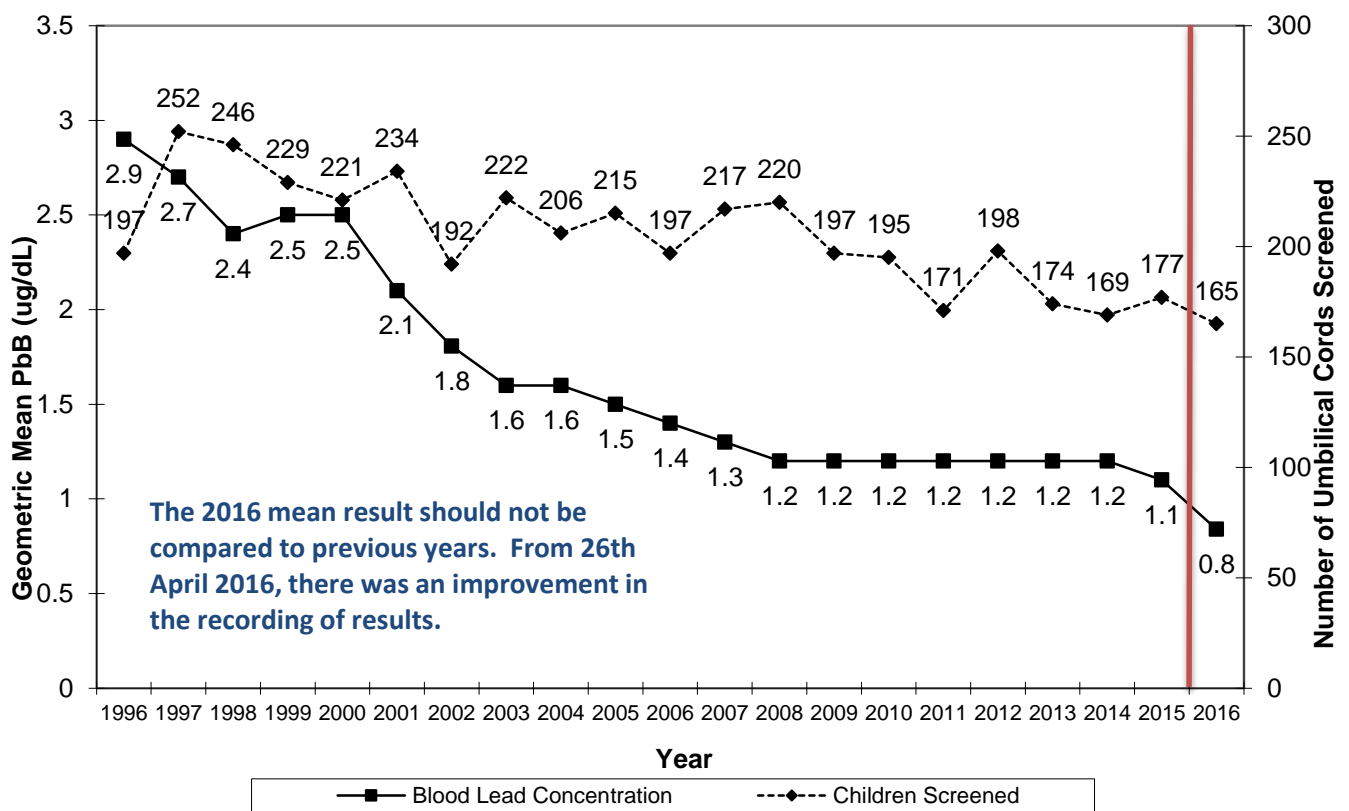


Figure 2. Geometric mean for cord blood lead (PbB) concentration and number of resident newborns screened at Broken Hill Health Service, 1996-2016.

Screening of Children Aged 1-4 years

Over the duration of the voluntary blood lead screening program there has been a decreasing trend in the geometric mean blood lead levels in all children tested (1-4 years), from a high of 16.7 $\mu\text{g/dL}$ in 1991 to an adjusted geometric mean of 5.9 $\mu\text{g/dL}$ in 2016 (Figure 3). The 2016 results remain stable compared to 2015 (5.8 and 5.9 $\mu\text{g/dL}$).

It is important to point out, that a significant improvement in the Aboriginal children results – 9.3 $\mu\text{g/dL}$ in 2015 to 7.6 $\mu\text{g/dL}$ in 2016 – has caused the ‘all children’ result to reduce. The non-Aboriginal children geometric mean has actually increased to 5.2 $\mu\text{g/dL}$ in 2016 – up from 4.9 $\mu\text{g/dL}$ in 2015 (Figure 3). Results for Aboriginal children are further explored later in the report.

The number of all children tested peaked in 1994, with 948 children screened, as a result of a major resource intensive door-knocking campaign in 1994 to raise awareness in the wider community. The

falling trend since then was reversed in 2011 with the inclusion of blood lead screening with routine immunisation at the Broken Hill Child and Family Health Centre and expansion of testing at Maari Ma Primary Health Care service.

In 2016 a total of 687 children had at least one test, a minor increase from the 679 tested in 2015. However, this increase was actually due to significant increases in Aboriginal children testing. The number of Aboriginal children tested increased from 178 to 207 (2015 to 2016) – representing a 16% increase. The reverse was true for non-Aboriginal children, with a reduction from 501 to 480, or a 4% decline (2015 to 2016). The percentage reduction in non-Aboriginal children participation is in line with the reduction in population between 2015 and 2016.

Blood lead levels and the number of children tested are both higher in the first half of the year (Figure 6). The number of children presenting for testing drops over the winter months. This may be a result of changes in health seeking behaviours in cooler months.

Blood lead levels in all children and children identifying as Aboriginal aged 1 – 4 years in Broken Hill, 1991-2016

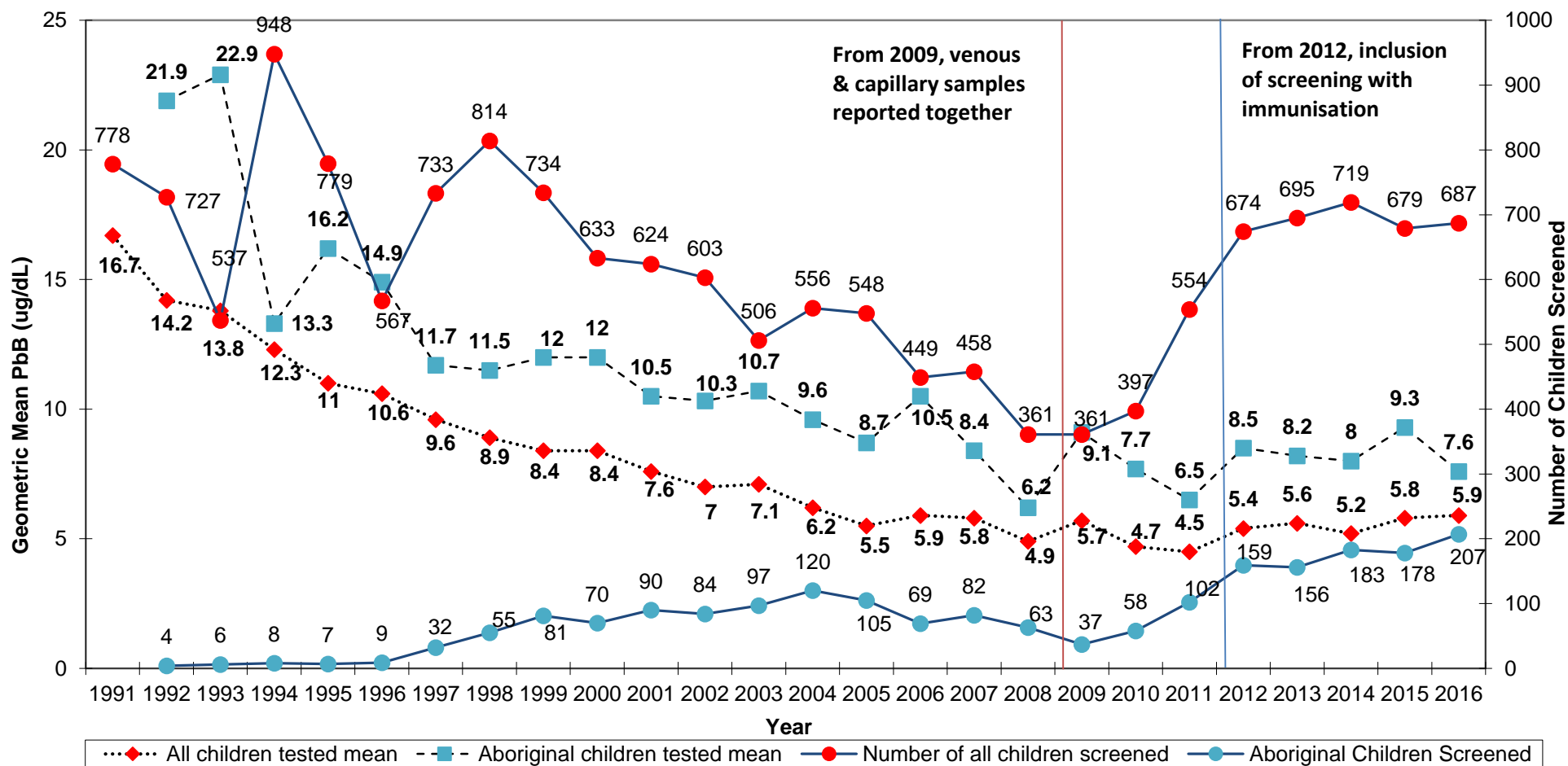


Figure 3. Population age-sex standardised geometric mean blood lead concentration and number of all children and Aboriginal* children screened aged between 1-4 years in Broken Hill, 1991-2016. The red line indicates the point in which both venous and capillary samples are reported together and the blue the inclusion of screening with childhood immunisation. *There were no recorded tests for Aboriginal children in 1991. Standardisation applied only from 1997 onwards, due to small sample size. Additionally, Aboriginal status was only consistently collected from 1997.

The proportion of all children with blood lead levels $< 5 \mu\text{g/dL}$ has risen from 13% in 2000 to 42% in 2016 (Figure 4). At the same time, the geometric mean has fallen from $8.4 \mu\text{g/dL}$ (2000) to fluctuate between 5 and $6 \mu\text{g/dL}$ since 2005. Although the proportion of all children with blood lead levels $< 5 \mu\text{g/dL}$ has increased from 2000 to 2016, the 2016 result actually represents the lowest proportion in this range since 2010, when 59% of all children had blood lead levels below $5 \mu\text{g/dL}$. There has been a decrease in the proportion of all children below $5 \mu\text{g/dL}$ since 2010, and an increase in the proportion of children in the 5 to $<10 \mu\text{g/dL}$ range – from 28% in 2010 to 38% in 2016. (Figure 4). Total numbers, instead of percentages, for each lead level category are presented in Figure 5.

Anecdotally, additional children may have been tested through alternative health care providers (e.g. private General Practitioners), however there is no obligation to forward these results to the Child and Family Health Centre, and therefore these results are excluded from this analysis. If results from a private practice return as $5 \mu\text{g/dL}$ or higher, this result will be notified to NSW Health (Public Health).

Percentage of children aged 1 – 4 years in Broken Hill by category of blood lead level and age-sex-standardised geomean by year

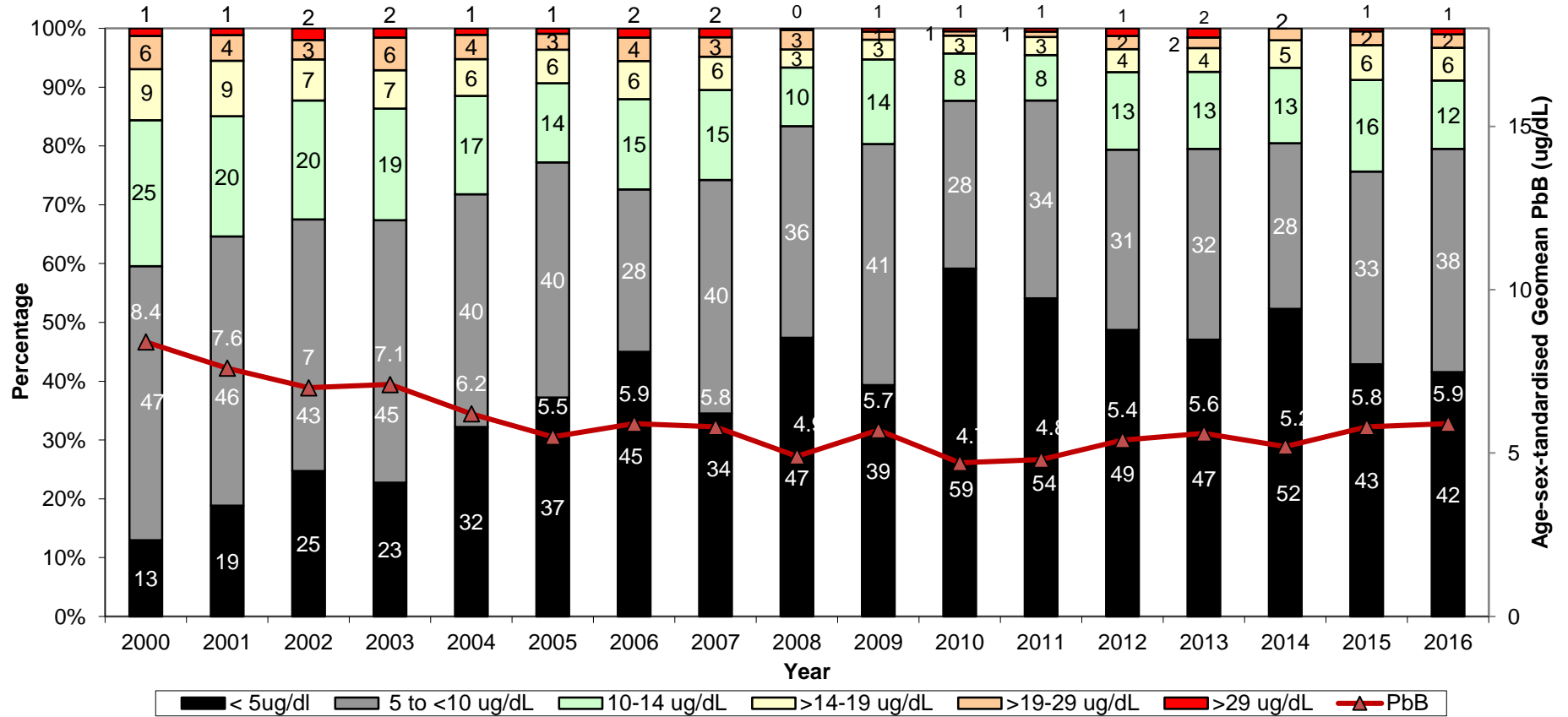


Figure 4. Age-sex standardised percentage of Broken Hill children aged 1 to 4 years in each blood lead category and population age sex standardised geometric mean (2000-2016).

Number of children aged 1 – 4 years in Broken Hill by category of blood lead level by year

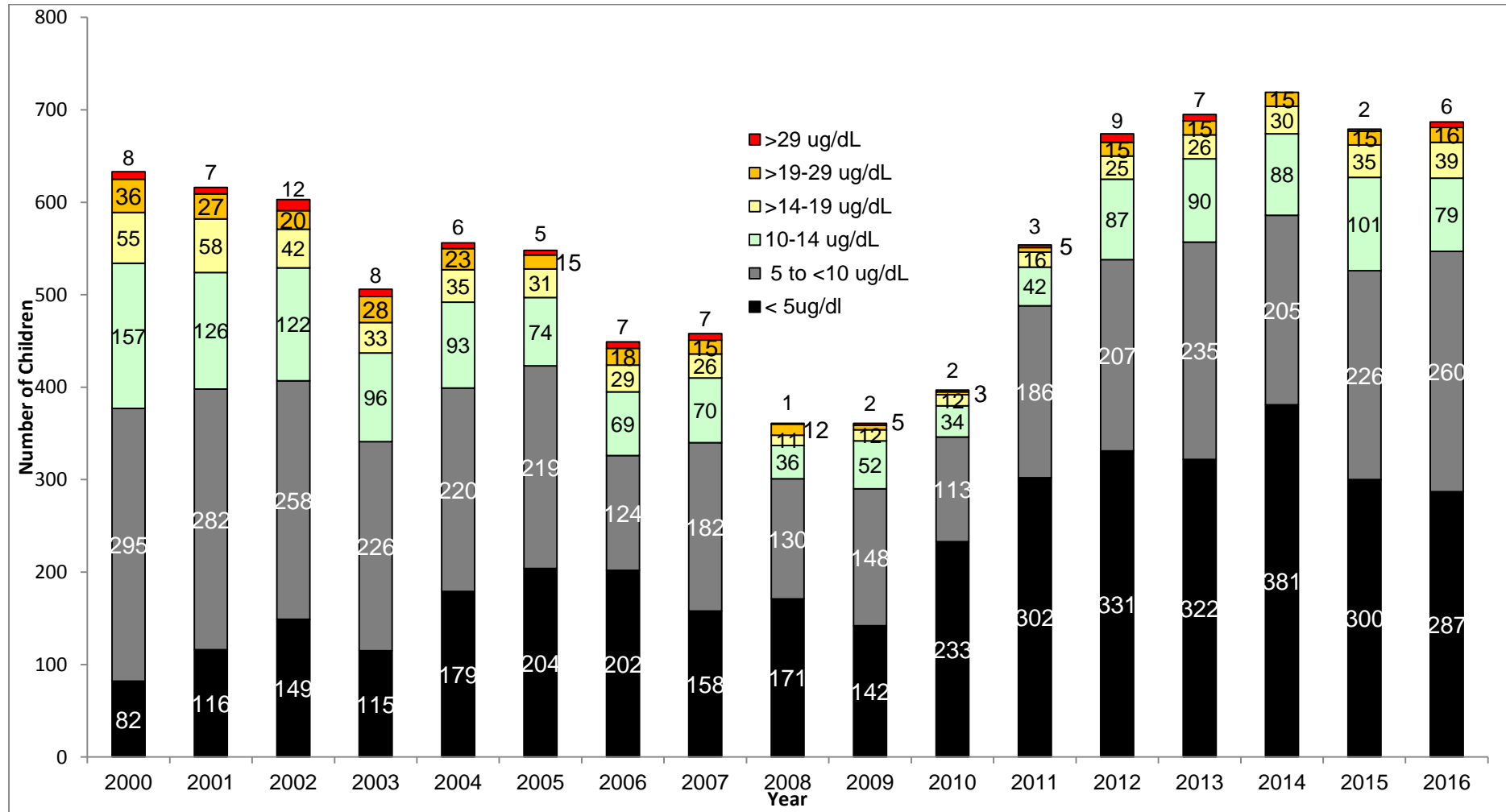


Figure 5. Count of all tested Broken Hill children in each blood lead category, aged between 1 and 4 years, 2000-2016.

Monthly mean blood lead levels and screening count of children aged 1 – 4 years in 2016

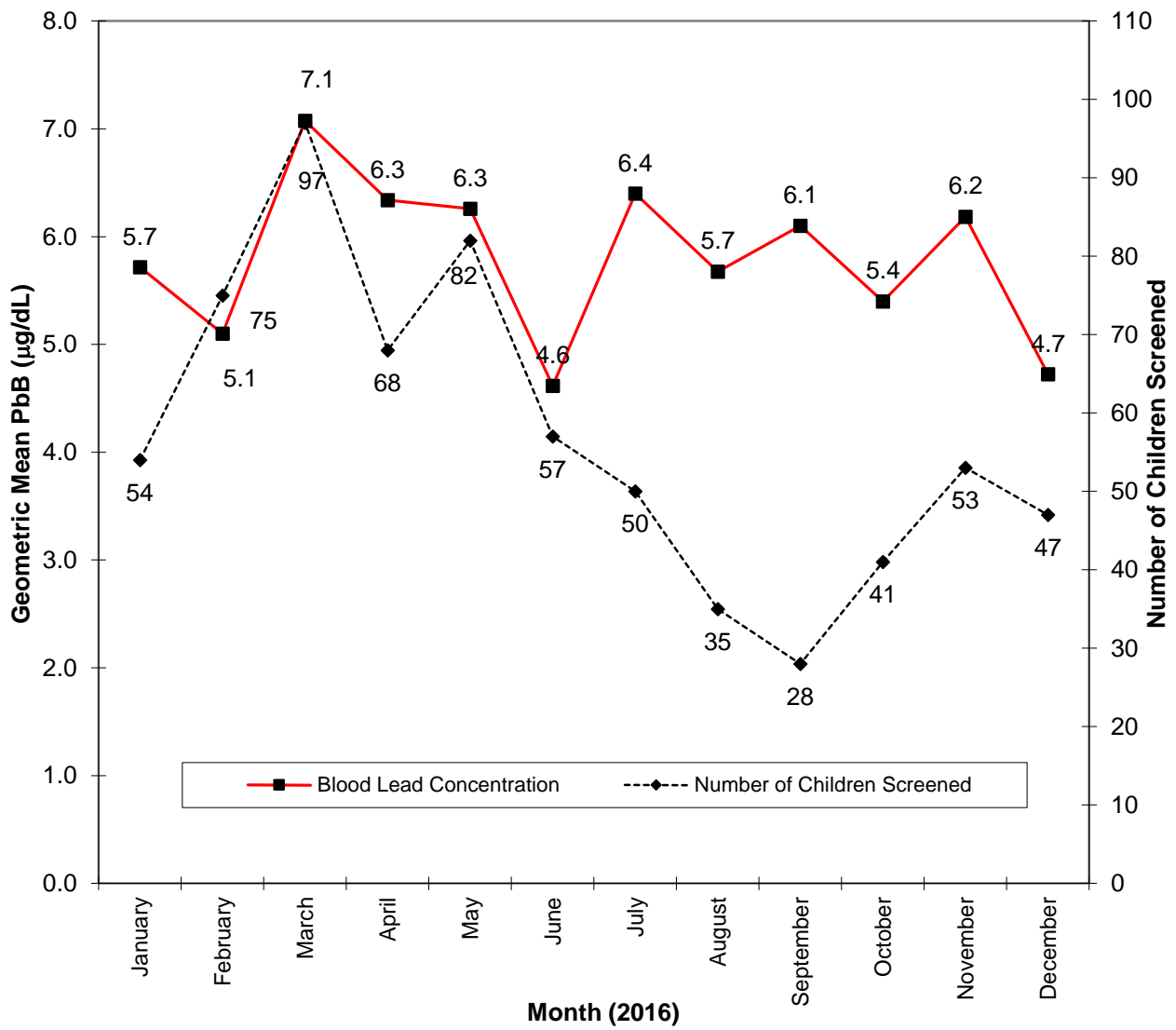


Figure 6. Monthly geomean comparison of first visit blood lead levels for Broken Hill children aged between 1 to 4 years of age for 2016.

Screening of Aboriginal Children Aged 1 to 4 years

There has been a historical burden of high blood lead levels in children identified as Aboriginal in Broken Hill. The mean blood lead level for Aboriginal children is higher than the overall geometric mean for all Broken Hill children, however this level has been decreasing. From 2011, when aligning blood lead testing with immunisation began, the proportion of children tested markedly increased.

In 2016 there was a significant decrease in the Aboriginal age-sex standardised mean, from 9.3 µg/dL (2015) to 7.6 µg/dL in 2016 (Figure 3). This compares to a slight increase in the non-Aboriginal children – 4.9 to 5.2 µg/dL (2015 to 2016 respectively). The average gap between Aboriginal and non-Aboriginal children was 2.4 µg/dL in 2016 – nearly halving that recorded in 2015.

From 2015 to 2016 there was a 16% increase in the number of Aboriginal children tested (178 to 207) – marking 2016 as the year with the highest number of Aboriginal children tested. Determining a participation rate (i.e. number tested divided by total number of resident Aboriginal children 1 to 4 years) is too unreliable. Aboriginality is significantly under reported in the Census. For example, the 2016 Census total for Aboriginal children aged 1 to 4 years is actually less than the total number tested – resulting in an estimated participation rate of over 100%.

In 2016, 22% of tested Aboriginal children had a blood lead level less than 5 µg/dL, the NSW Health notifiable level for 2016. Although this represents an increase from 2015 (17%), it contrasts greatly to a 50% proportion of non-Aboriginal children <5 µg/dL. While there was an improvement from 2015 to 2016 in the proportion of Aboriginal children with blood lead level results less than 5 µg/dL, previous years have seen a higher proportion of blood lead results under 5 µg/dL. For example, 37% of Aboriginal children had blood lead results under 5 µg/dL in 2008 (Figure 7). In 2016, the 5 to < 10 µg/dL category has the highest proportion of the Aboriginal children results (43%) – this lead range has been the highest proportion since 2011.

The discrepancies in blood lead levels between Aboriginal and non-Aboriginal children are greatest in the < 5 µg/dL category (Figure 8) – 22% compared to 50% (Aboriginal and non-Aboriginal respectively). In all other lead range categories (i.e. all above 5 µg/dL), the Aboriginal children proportion is higher than the non-Aboriginal children.

The expansion of the blood lead screening program has resulted in a more accurate depiction of the burden of blood lead levels among Aboriginal children. This more accurate picture can better inform public health action to reduce the blood lead level discrepancy between Aboriginal and non-Aboriginal children in Broken Hill.

Percentage of Aboriginal identified children aged 1 – 4 years for each category of blood lead level, 2000-2016

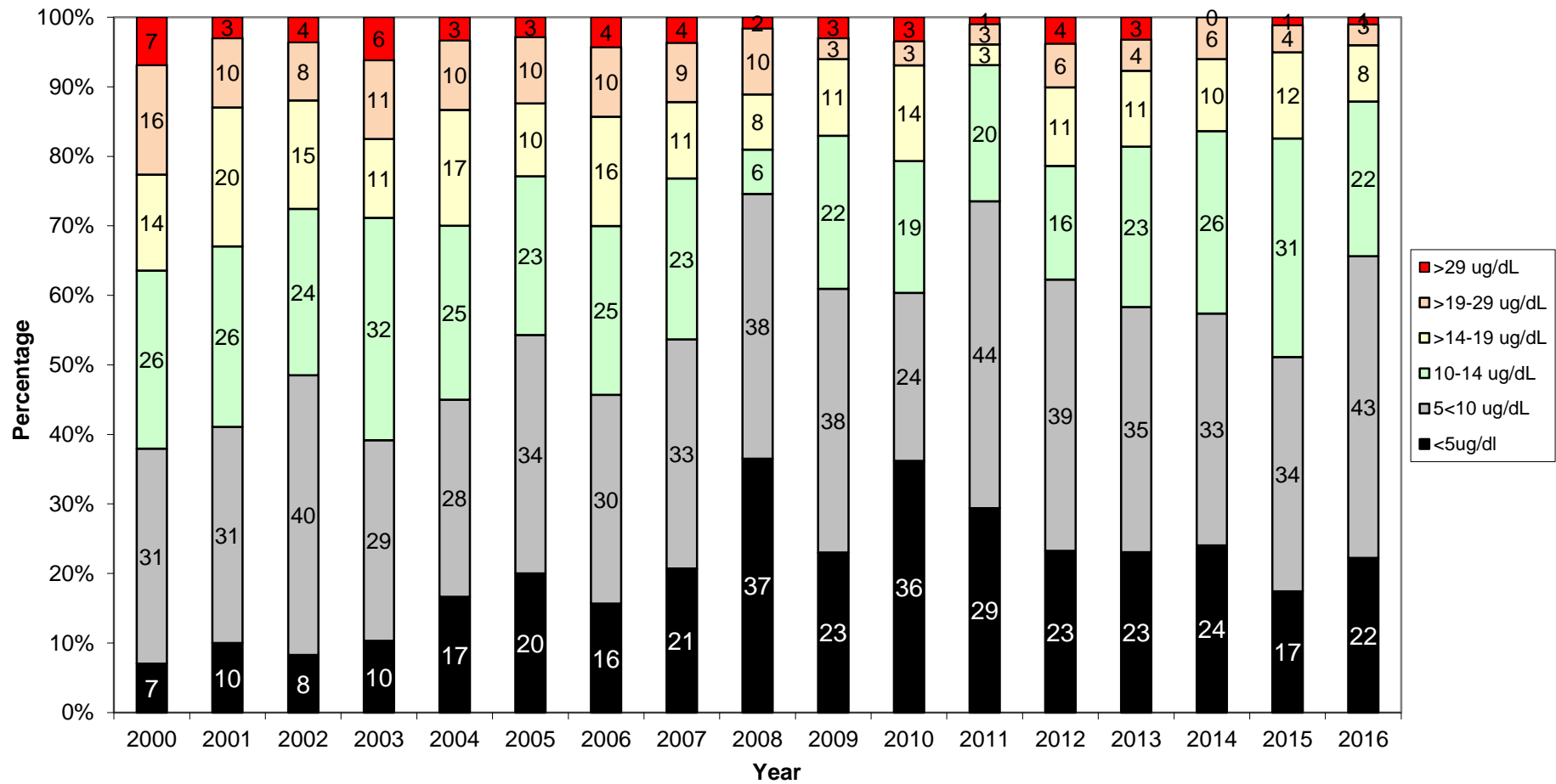


Figure 7. Percentage of Broken Hill Aboriginal children in each blood lead category, aged between 1 and 4 years, 2000-2016. Data is presented from 2000 as before that the proportion and number of Aboriginal children tested was small, additionally caution should be used with the 2006 – 2010 results as this was also a period of low attendance by Aboriginal children.

Blood lead level categories by Aboriginal status for children aged 1 – 4 years, Broken Hill, 2016

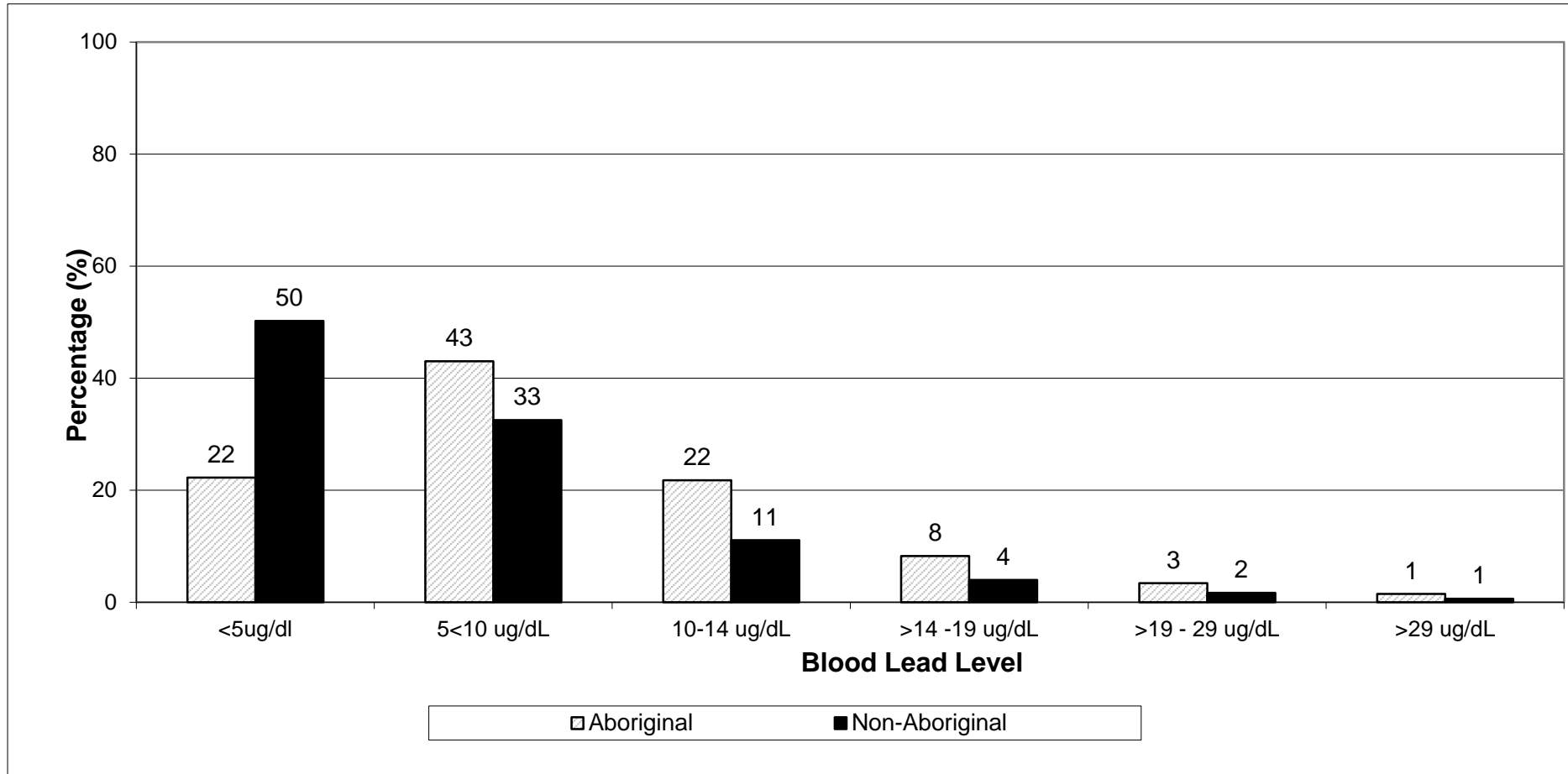


Figure 8. Comparison of Aboriginal versus non-Aboriginal aged 1-4 years by blood lead categories (2016).

Estimate of Participation Rate

The estimated participation rate for lead screening in children at Broken Hill (1 to 4 years) was 88% in 2016. There have been significant increases since the period 2008-2010 (rates around forty percentage) to close to 80% and above from 2012 (Figure 9). There is significant under reporting of Aboriginality in the Census, and for 2016 the count of 1 to 4 year old Aboriginal children is actually less than the total tested in Broken Hill (159 compared to 207). Therefore, no participation rate calculation for Aboriginal children was performed, as the result exceeds 100%.

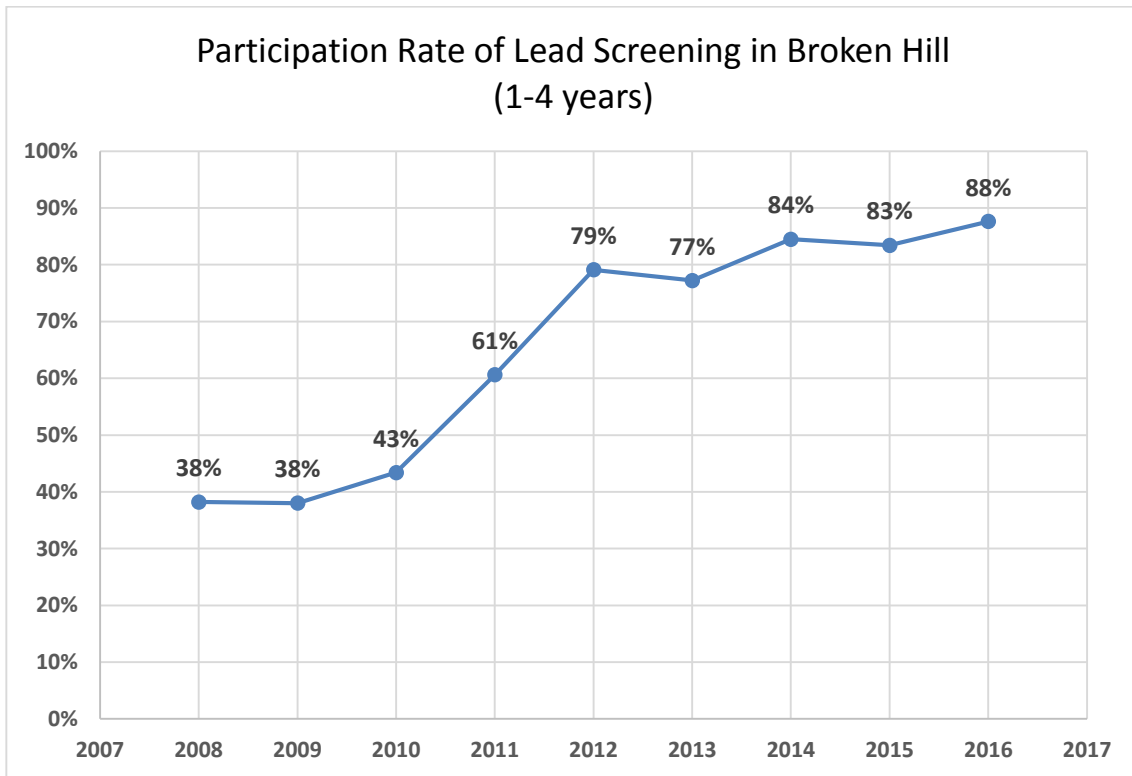


Figure 9. Estimate of blood lead level screening participation rates for Broken Hill children (1 to 4 years).

Conclusion

Geometric means (age-sex standardised) for all children tested (1 to 4 years) increased slightly from 2015 – 5.8 to 5.9 µg/dL in 2016. The Aboriginal children blood lead mean result improved significantly in 2016 decreasing from 9.3 to 7.6 µg/dL, however there was an increase observed in the non-Aboriginal children results – 4.9 to 5.2 µg/dL (2015 to 2016).

In addition to significant improvements in the geometric mean for Aboriginal children, the total number of Aboriginal children screened increased by 16% from 2015 to 2016. In 2016, a total of 207 Aboriginal children were tested – the highest number on record. The alignment of immunisation and blood lead testing, as well as the strengthening of the partnership between the Child and Family Health Centre and Maari Ma have been major factors in reversing the previous decline in children's participation in screening.

The 2016 results show 50% of non-Aboriginal children in Broken Hill had a blood lead level below 5 µg/dL, compared to 22% of Aboriginal children. Although there is a large gap between Aboriginal and non-Aboriginal children in the proportion under the notifiable blood lead level of 5 µg/dL, the difference in geometric mean levels was almost halved, from 4.4 in 2015 to 2.4 in 2016.

There remains ongoing work to reduce blood lead levels in Broken Hill. While there have been improvements across some lead results for children, there have been increases over time to the proportion of children with blood lead levels above 5.0 µg/dL – from 41% in 2010 to 58% in 2016. In particular, reducing blood lead levels among Aboriginal children to match those of non-Aboriginal children remains a challenge

Appendix 1

The criteria for birthing in Broken Hill is that they have to be low risk.

The following women are not eligible to give birth in Broken Hill:

- Less than 37 weeks gestation
- BMI >45 at 36 weeks gestation
- High risk comorbidities requiring specialist treatment
- Uncontrolled gestational diabetes
- Severe intrauterine growth restrictions/foetal abnormalities
- High risk pre-eclampsia
- High risk twins or triplets
- Women with type 1 diabetes
- Induction of labour or caesarean prior to 38 weeks gestation

All of the above women are referred to Flinders Medical Centre or Women's & Children Hospital, Adelaide.

References

Australian Bureau of Statistics (ABS), Census of Population and Housing, 1996, 2001, 2006 and 2011

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