Lead Report Summary 2020:

Broken Hill children less than 5 years old

Broken Hill University
Department of Rural Health

NSW GOVERNMENT Health
Far West
Local Health District

Acknowledgements

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Table of Contents

Background

History of Lead poisoning in Broken Hill

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. Unlike many other naturally found metals, lead and lead compounds are not beneficial or necessary for human health, and can be harmful to the human body 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.

A 1991 survey of 1-<5 year-old Broken Hill children found that 86% had blood lead levels of 10µg/dL or above and that 38% had very high lead levels of 20µg/dL or above. Since 1991, parents/carers in Broken Hill have been offered free voluntary blood lead screening for children under the age of 5 years old. From 1996, newborn umbilical cord blood has been tested to determine the impact of lead transfer from the mother to the child.

Currently lead screening is encouraged through the combination of: reminders via text message; aligning lead testing with the immunisation schedule; and promotions and advertising in the local media.

Integral to the problem of lead in Broken Hill is the hot, dry climate. Seasonal effects on blood lead are reported in Broken Hill, as elsewhere. The climate changes predicted for Far West NSW are likely to enhance dust storms, soil dispersion and elevate lead (Pb) dust loading into the environment.

Australian Lead Guidelines

The National Health and Medical Research Council (NHMRC) provides health advice and health guidelines for the Australian community, governments and health professionals. One of the NHMRC's tasks is to advise the Australian community about lead exposure and the health effects of lead and how they can be managed.

Notifiable Blood Lead Levels

NSW Health set the blood lead notification level at 10 µg/dL from 1993, however, in May 2015, the NHMRC completed an evidence review and issued a statement for a revised blood lead notification level of 5 µg/dL. 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 adults. In addition, the World Health Organisation reports that blood lead levels as low as 5 µg/dL may be associated with decreased intelligence in children, behavioural difficulties and learning problems

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.

Results

Screening of Newborns

In 2020, there were 176 live births at Broken Hill Hospital (including by women who live elsewhere). Of babies who had a Broken Hill address at birth or at their 6 month test, cord blood was taken for lead testing, 3 babies with clotted cord bloods were excluded and 4 other babies were also excluded as there was no cord blood result so were likely not tested. In all 122 successful tests are reported.

The geometric mean of umbilical cord lead level was 0.6 µg/dL, in 2020 (Figure 1). While the overall trend from 2011 shows the reduction in blood lead levels over time, the actual geomeans cannot be compared against years prior to 2016. This is because there was an improvement in recording cord blood levels, through the inclusion of decimal points, resulting in greater accuracy since 26 April 2016.

Of newborns with a valid test 80% (n=98) were non-Aboriginal. All newborns, regardless of Aboriginality, had blood lead levels below the notifiable level. At this age there is very little difference in geomeans between non-Aboriginal and Aboriginal infants (0.5 µg/dL v 0.9 µg/dL respectively).

Umbilical Cord Blood Lead Screening in Broken Hill newborns 1996-2020

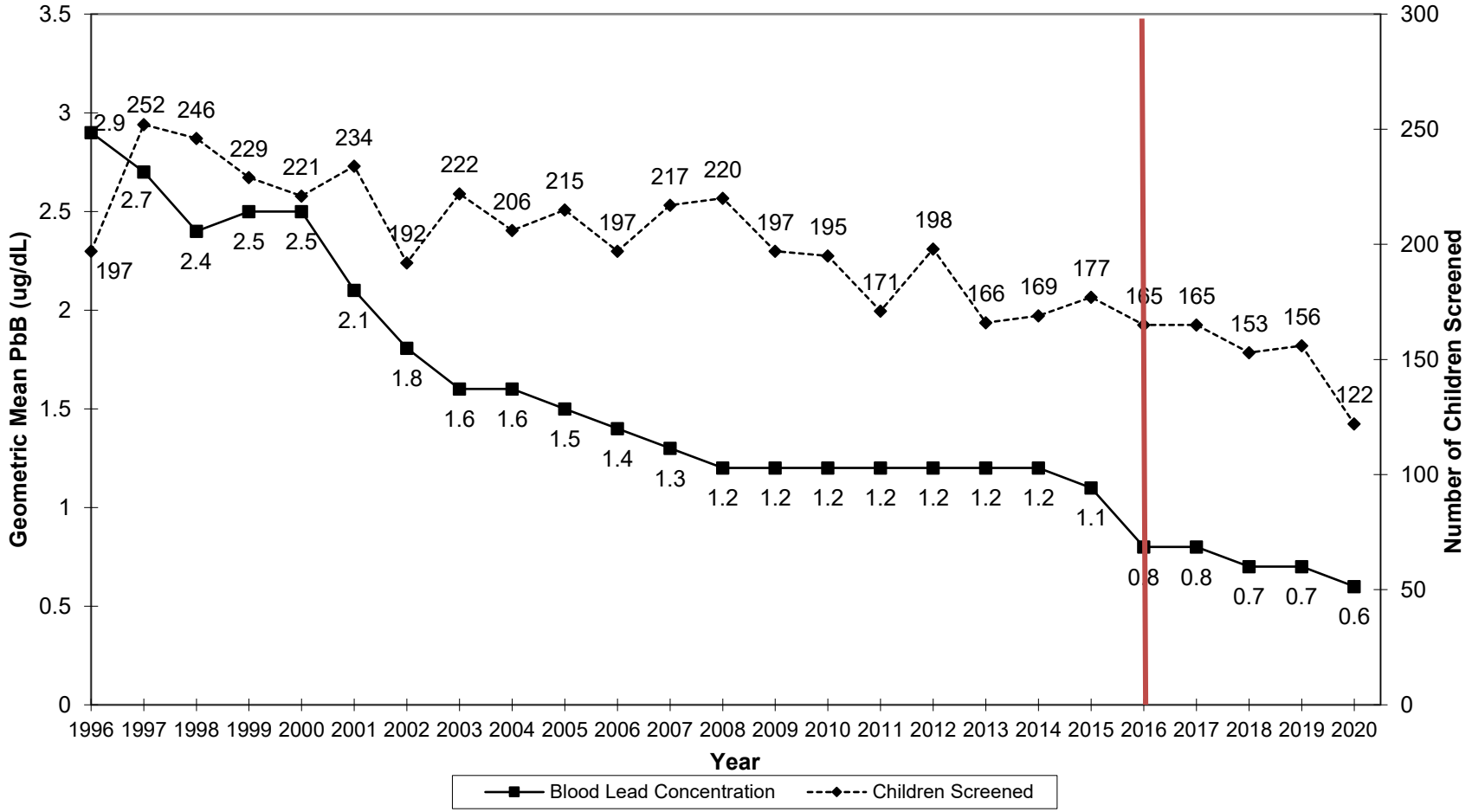

Figure 1. Geometric mean for cord blood lead (PbB) concentration and number of resident newborns screened at Broken Hill Health Service, 1996-2020. The vertical red line is indicative of the improvements made in the recording of results since 26th of April 2016. The geometric means collected since 2016 should not be compared to the previous years. See Methods- Reporting of Blood Lead Levels.

Screening of All Children Aged 6 months to < 12 months

From 1991 to 2012, testing was conducted on children aged between 6 months to < 12 months. In 2012, the geometric mean of children under 1 year was 3.9 µg/dL; 25% of children tested would have had notifiable levels using current guidelines (5 µg/dL).

The lead testing for this age group was discontinued from 2013 to 2017 because of two reasons: resourcing constraints and the preliminary results showed that geometric mean blood lead levels of children in this age group were well below the notifiable level at that time (10 µg/dL).

The lead testing recommenced in 2018 for children aged between 6 months to < 12 months of age. In 2020 a total of 222 children were tested with a geometric mean of 2.7 µg/dL (Figure 2), which was a decrease of 1.2 µg/dL from the testing that was done in 2012. Additionally, the proportion of children who had blood lead levels above the current notifiable level (5 µg/dL) fell to 13% from 25% in the same period (Figure 3).

Of all children tested 74% (n=164) identified as non-Aboriginal. Non-Aboriginal newborns had a geomean of 2.6 µg/dL and Aboriginal newborns had a slightly higher geomean of 2.8 µg/dL.

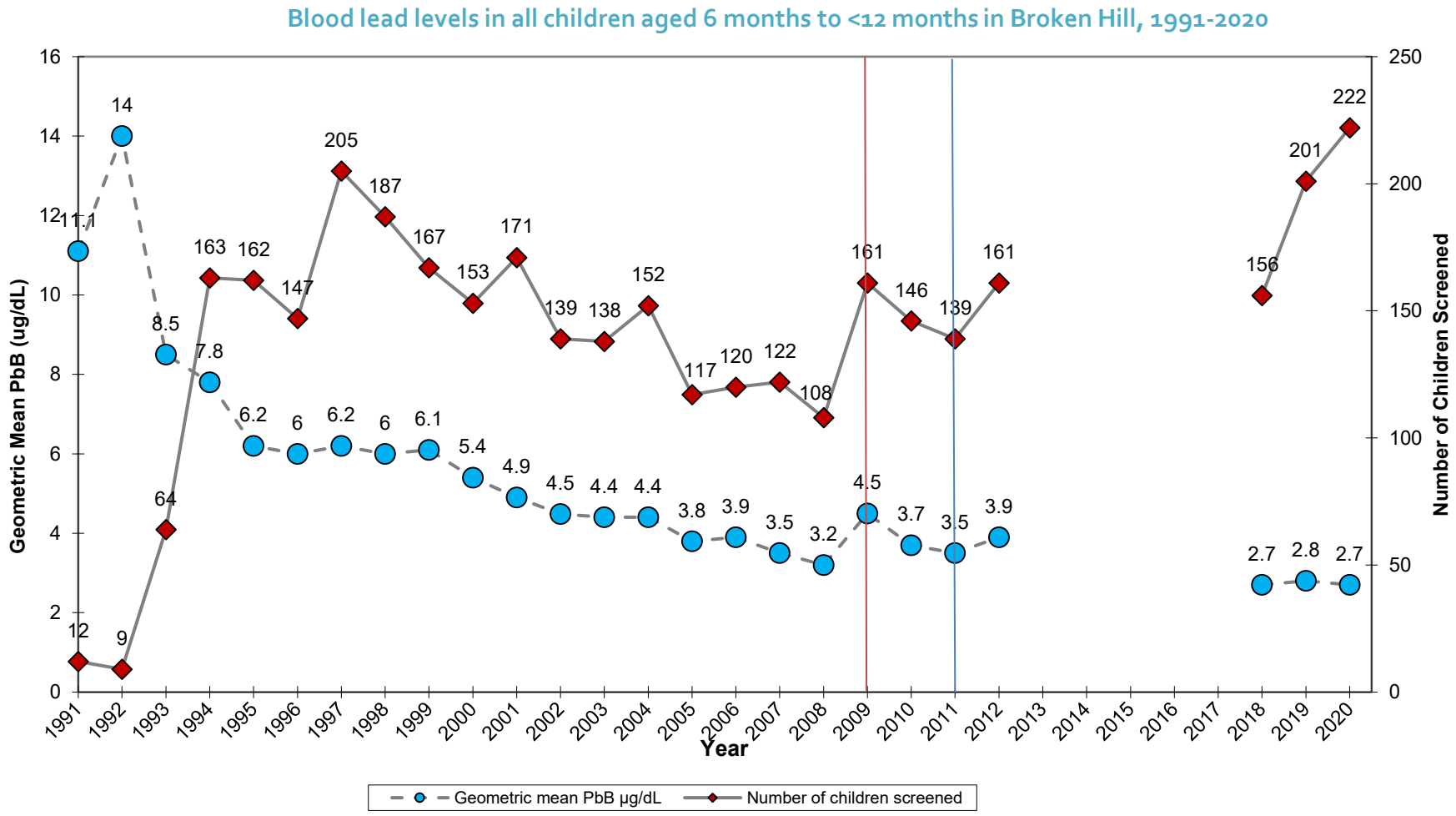

Figure 2. Geometric mean blood lead concentration and number of children screened aged 6 months to <12 months in Broken Hill, 1991-2020. The red vertical line indicates the point in which both venous and capillary samples are reported together and the blue vertical line indicates the point in which the lead testing was aligned with childhood immunisation. The geomean collected since 2018 cannot be compared to previous geomeans as recording of results and use of the capillary method affects geomeans. See Methods – Reporting of Blood Lead Levels.

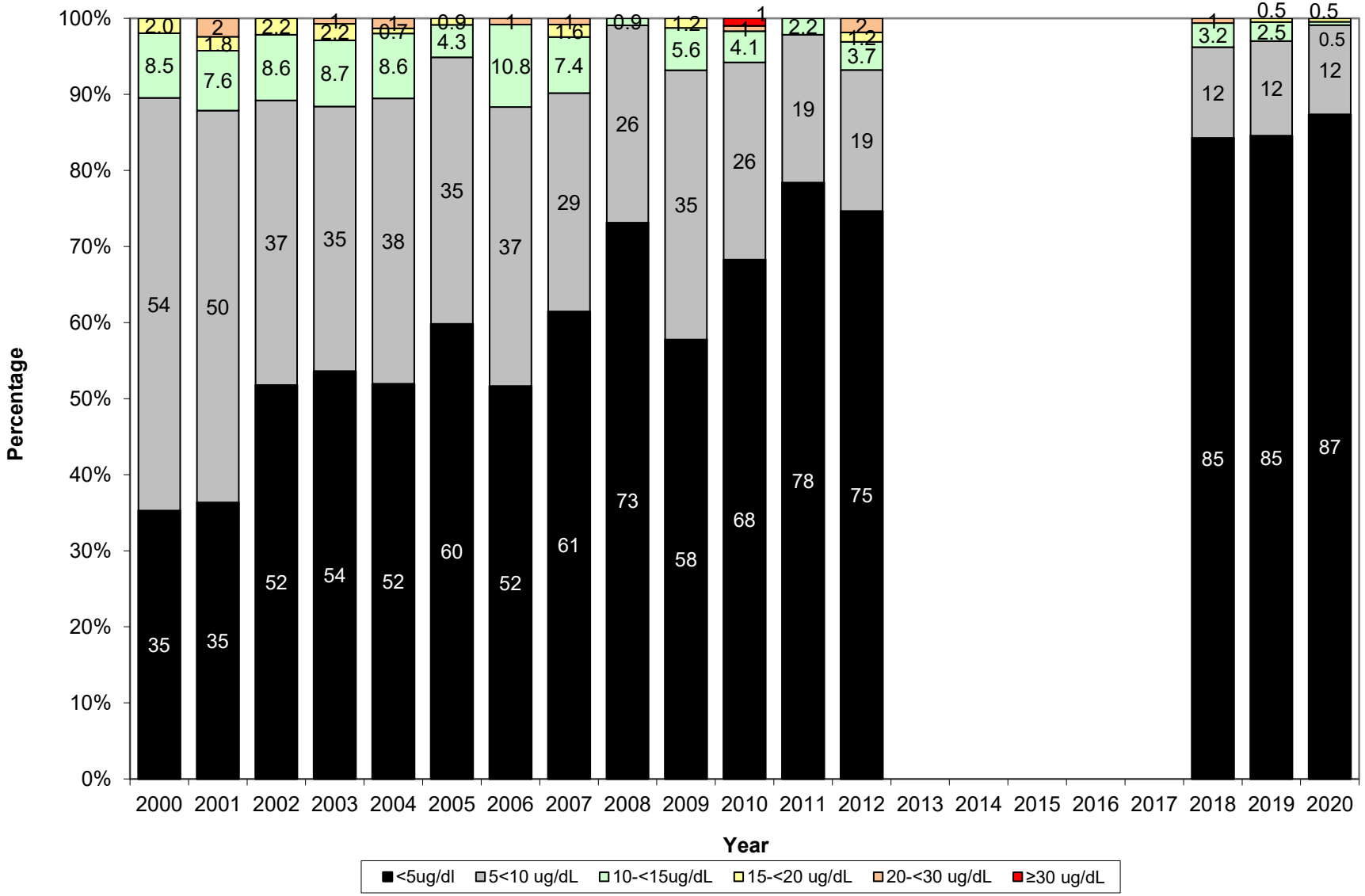

Figure 3. P ercentage of Broken Hill children aged 6 months to <12 months in each blood lead category (2000-2020).

Screening of Children Aged 1 to < 5 years

Screening of Aboriginal and Non-Aboriginal children aged 1 to <5 years

Figure 4 shows the overall decrease in blood lead levels in all children and Aboriginal children from 1991. Over the last 10 years the geomean for all children has remained around 5 µg/dL, while the geomean for Aboriginal children is 3-4 µg/dL higher over this period.

In 2020, a total of 689 children had at least one test, an increase of 7% from children tested in 2019 and their geomean decreased to 4.7 µg/dL (Figure 4). The proportion of all children with blood lead levels under the benchmark (<5 µg/dL) has risen from 13% in 2000 to 54% in 2020, with Figure 5 and Table 1 showing that since 2011 the proportion has fluctuated between 42-54%.

The total number of children tested in 2020 has remained high consistent with recent years, however, the number of children in the <5 µg/dL category is greater than seen in these years (Table 1). The proportion of children in categories above 5 decreased in 2020 compared to 2015, 2016 and 2019 (Figure 6).

Table 1 Blood lead levels in all children aged 1 to <5years in Broken Hill, 2011-2020

Year	Number of all children tested	Geomean of children tested (µg/dL)	Number of all children tested <5 µg/dL	Proportion of all children tested <5 µg/dL
2011	554	4.5	302	54
2012	674	5.4	331	49
2013	695	5.6	322	47
2014	719	5.2	381	52
2015	679	5.8	300	43
2016	687	5.9	287	42
2017	730	5.7	344	46
2018	637	4.7	329	51
2019	681	5.1	334	48
2020	**689**	**4.7**	**376**	**54**

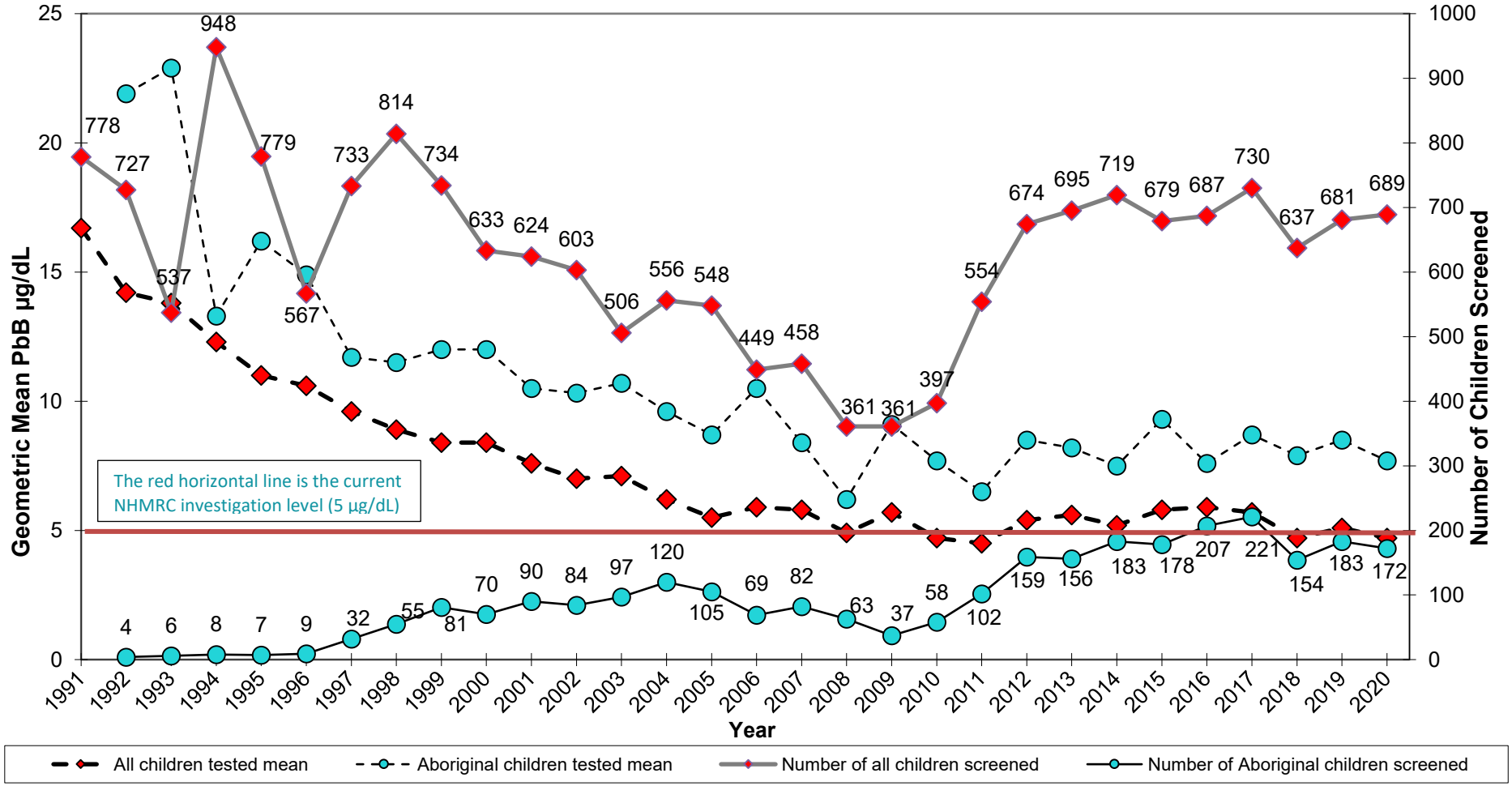

Figure 4. Population age-sex standardised geometric mean blood lead concentration and number of all children and Aboriginal* children screened aged between 1 to <5 years in Broken Hill, 1991-2020. 2009 was the year both venous and capillary samples were first reported together; 2011 the inclusion of screening with childhood immunisation. Standardisation applied only from 1997 onwards, due to small sample size. *There were no recorded tests for Aboriginal children in 1991, Aboriginal status was only consistently collected from 1997. The geomeans reported since 2016 cannot be compared to previous geomeans as recording of results and use of the capillary method affects geomeans.

Percentage of children aged 1 – <5 years in Broken Hill by category of blood lead level by year

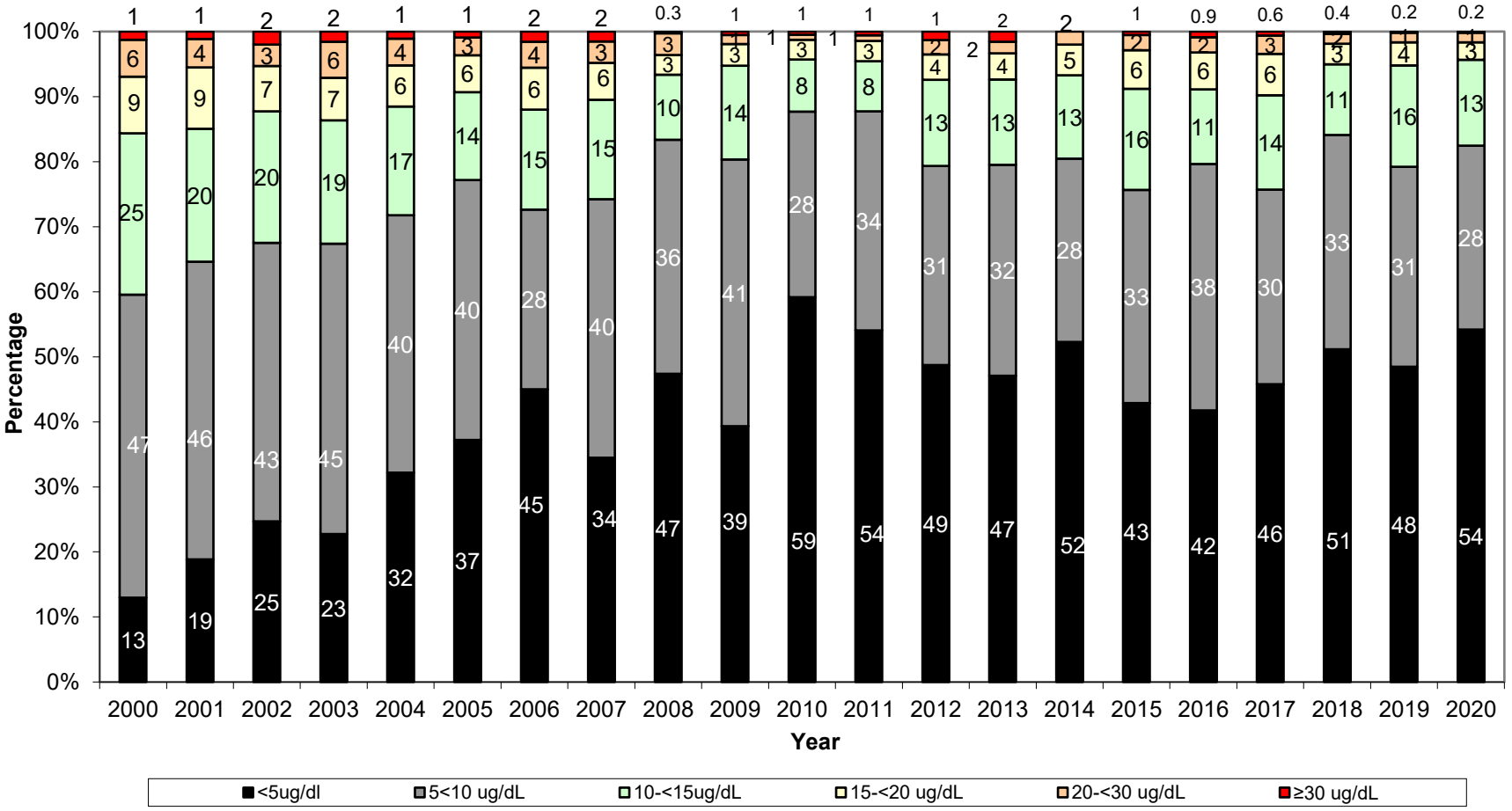

Figure 5. Age-sex standardised percentage of Broken Hill children aged 1 to <5 years in each blood lead category and population age sex standardised geometric mean (2000-2020).

Number of children aged 1 to <5 years in Broken Hill by category of blood lead level by year

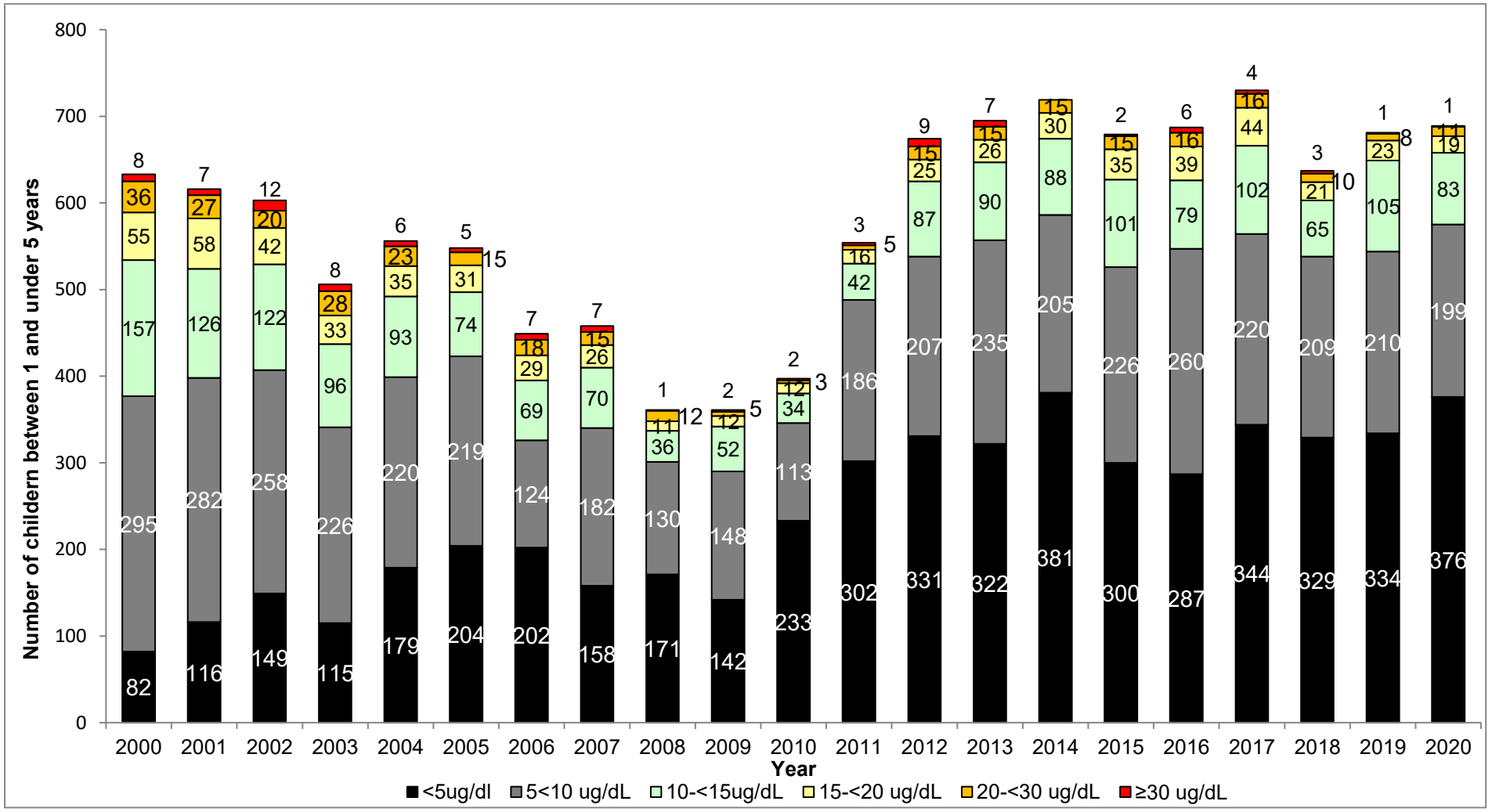

Figure 6. Count of all tested Broken Hill children in each blood lead category, aged between 1 to <5 years, 2000-2020.

Screening of Aboriginal Children aged 1 to <5 years

Blood lead screening for Aboriginal children aged 1 to <5 years has its own section as the historical burden of high blood lead levels in Aboriginal children in Broken Hill has been most evident in children aged 1 to <5 years. Unlike the results for cord blood and children aged 6 months, this age group reveals substantial differences between Aboriginal and non-Aboriginal children.

The mean blood lead level for Aboriginal children is higher than the mean for all Broken Hill children. Since 2011 Maari Ma has delivered blood lead testing and, along with the alignment of testing to immunisation schedules, the number and proportion of children tested has markedly increased.

In 2020, the number of Aboriginal children tested decreased slightly from 183 to 172. There was also a slight decrease in the Aboriginal age-sex standardised mean, from 8.5 µg/dL (2019) to 7.7 µg/dL in 2020 (Figure 4, Table 2). The gap between Aboriginal and non-Aboriginal children blood lead levels of 3.7 µg/dL has remained stable since 2015.

In 2020, 30% of tested Aboriginal children had a blood lead level less than 5 µg/dL, an increase from the proportions since aligning screening with immunisation (Figure 7). The discrepancies in blood lead levels between Aboriginal and non-Aboriginal children are greatest in the <5 µg/dL category (Table 2, Figure 8) – 30% compared to 63% (Aboriginal and non-Aboriginal respectively). In the 10 years previous to 2020 the proportion of Aboriginal children < 5 µg/dL averaged 22% while the average for the non Aboriginal children was 58% (Figure 8).

Table 2 Blood lead levels in Aboriginal and non Aboriginal children aged 1 to <5years in Broken Hill, 2011-2020

Year	Number of Aboriginal children tested	Geomean of Aboriginal children tested (µg/dL)	Number of Aboriginal children who tested <5 µg/dL	Proportion of Aboriginal children tested <5 µg/dL	Number of non Aboriginal children who tested <5 µg/dL	Proportion of non Aboriginal children tested <5 µg/dL
2011	102	6.5	30	29	272	60
2012	159	8.5	37	23	296	57
2013	156	8.2	36	23	299	55
2014	183	7.5	44	24	337	63
2015	178	9.3	31	17	270	54
2016	207	7.6	46	22	241	50
2017	221	8.7	48	22	296	58
2018	154	7.9	37	24	291	61
2019	183	8.5	37	20	292	60
2020	**172**	**7.7**	**51**	**30**	**324**	**63**

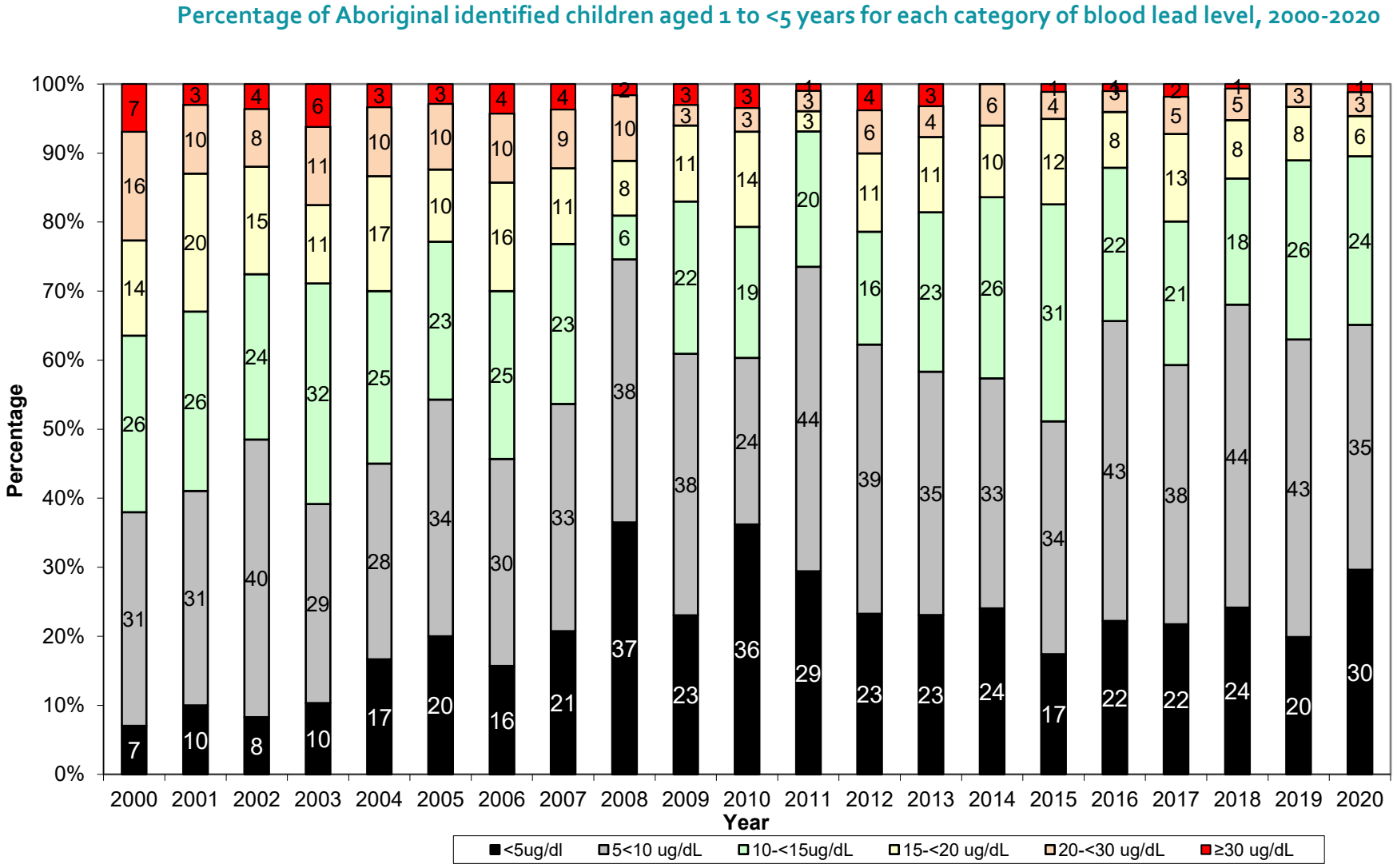

Figure 7. Percentage of Broken Hill Aboriginal children in each blood lead category, aged between 1 to < 5 years, 2000-2020. Data is presented from 2000 as before that the proportion and number of Aboriginal children tested was small, additionally caution should be used with the 2006 – 2010 results as this was also a period of low attendance by Aboriginal children.

Blood lead level categories by Aboriginal status for children aged 1 to <5 years, Broken Hill, 2020

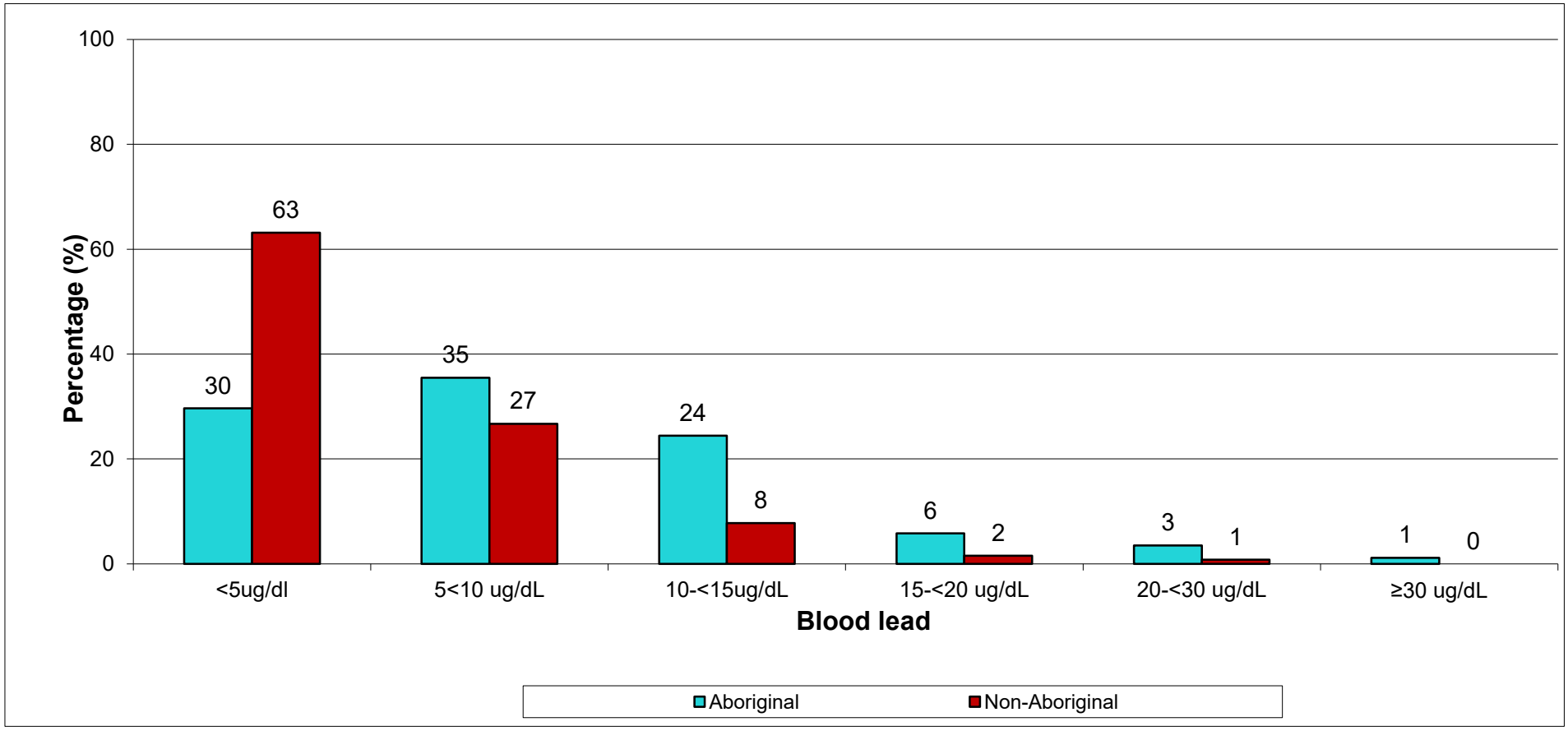

Figure 8. Comparison of Aboriginal versus non-Aboriginal aged 1 to <5 years by blood lead categories (2020).

Seasonal changes in blood lead levels of all children aged 1 to < 5 years

Seasonal analysis showed that the highest blood lead levels were generally between January-March/ April, increasing in warm/ hot dry weather, which also corresponds with many children having their first test (Figure 2). The total rainfall, 174mm, was still well under the median and a maximum temperature record was set in 2020. Most rain (78%, 136mm) occurred in the second half of the year, with 111mm falling between August and October.

Small monthly decreases in geomeans in the latter half of the year are seen in 2020 as also were seen in 2017, 2018 and 2019 (see previous annual reports), however the first three months in a year remain essentially the same. Special attention to decreasing blood lead levels in these months will affect a large number of children and therefore the overall population blood lead levels. The number of children is always greater in the first half of the year because reporting uses the first test in the calendar year.

Monthly mean blood lead levels and screening count of children aged 1 to <5 years in 2020

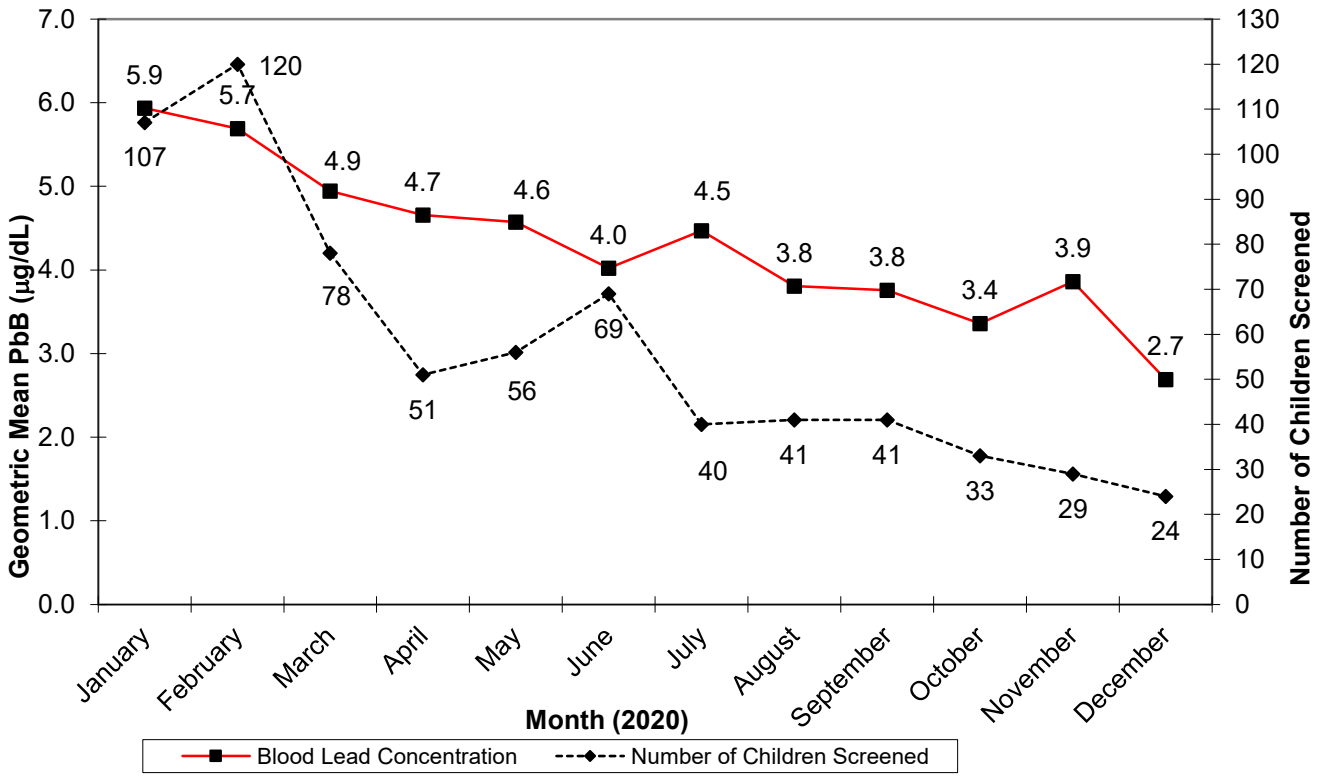

Figure 9. Monthly geometric mean blood lead level comparison of first visit blood lead levels for Broken Hill children aged between 1 to <5 years of age for 2020.

Conclusion

The Lead Testing Program performed well during 2020. The total number of children screened aged 1 to <5 years remained high, despite COVID-19 restrictions, (to 689 in 2020 compared with 681 in 2019).

While population blood lead levels fluctuate from year to year, the underlying trend is that levels have not changed significantly since 2012. In 2020 newborns had a geomean of 0.6 µg/dL; children aged between 6 months to <12 months had a geomean of 2.7 µg/dL; and the age-sex standardized geometric mean for children aged 1 to <5 years was 4.7 µg/d. Less than half (46%) of the children aged 1 to <5 years and only 13% of children aged 6 months to < 12 months had a notifiable blood lead level (<5 µg/dL)

Once children become toddlers (ie are 1 year and older) they have greater freedom to roam and explore. This increases children's exposure to lead and it is when diverging blood lead levels are observed between Aboriginal and non-Aboriginal children. Aboriginal children aged 1 to < 5 years were nearly twice as likely as to have a notifiable blood lead level <5 µg/dL than non-Aboriginal children (70% compared with 37% respectively)

The COVID-19 pandemic disrupted many aspects of society and the effects of restrictions around gatherings in public places may have affected screening attendances, but the number of children screened would suggest otherwise. C&FHC staff made a concerted effort to accommodate children and followed up those who didn't come for a scheduled recall visit, getting them tested in the latter half of the year. As well parents mentioned during clinic consultations that the recommended preventative measures against COVID-19 like hand hygiene, reinforced the behaviour for children as well as adults. Many aspects of the BHELP program, however, other than continuation of dust monitoring, were stopped or curtailed in 2020.

Analysis Methods

Screening Program logic

The program has targeted children under 5 years old as they are more susceptible to the adverse health effects from lead than adults.

The program has evolved over time to collect blood lead samples from three distinct groups of children aged under 5 years. These groups follow the developmental progression of children from completely dependent to physically independent. Comparison of blood lead levels across the groups informs both intervention need and monitoring of the lead program.

The first two groups that started the program in 1991 were children aged between 1 year and less than 5 years and those aged 6 months to < 12 months. The first age group of children are generally able to

move freely to interact with their environment. The second group are learning to explore their environment by putting objects into their mouth and have limited mobility through crawling but may be restrained outside.

The introduction of newborn screening in 1996 assists in determining the impact of lead diffusion across the placenta from the mother to the unborn child and could be considered as a defacto baseline for children.

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 five years are taken as either a finger prick (capillary) or venous test. Since October 2008, parents have had the option of having their children aged 6 months and over screened with a less invasive capillary sampling (finger prick) method.

Since 2011, lead screening was aligned with immunisation for children aged from 6 months to <5 years as well as health checks in the 1 to < 5 years age group. Testing may occur over the immunisation schedule (current schedule includes vaccinations at 6 months, 12 months, 18 months and 4 years of age) and health checks at 2 and 3 years of age. Therefore, a child may present at 6 months and 12 months, 12 months and 18 months or 18 months and 2 years (in line with health checks) 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. Due to higher immunisation frequency between the ages of 1 to 3, more children within this age group are included to the study.

Children who had a 6 month and 12 month test in 2020 calendar year may be represented in two sections of the report. First in the 6 months to <12 month testing group and when they turned 12 months included in the children aged 1 to < 5 years analysis.

Reporting of Blood Lead Levels

For analysis and reporting purposes in the 1 to < 5 year group, only a child's first test in this age group in the calendar year is used for calculations, to ensure only one result per child per year.

The geometric mean (instead of an arithmetic mean or average) is used to report blood lead levels throughout this report. Where most children have lower blood lead levels and a proportion have very high levels, the arithmetic mean is strongly affected by the very high values. The geometric mean gives a value which is closer to that of most children.

Recording of blood lead levels has changed over time:

- From 1991 till 2016 all blood lead results were rounded up or down when recorded in the data base. The reason for this practice is unclear, but may have been related to the capabilities of the original Access® database.
- Capillary results were first reported from 2009 onwards. The minimum reading possible for capillary sampling is 3µg/dL compared to <1µg/dL for venous sampling. A "low result" reading is also possible and nurses were instructed to record this as 2 ug/dl. This will affect the geomeans

calculated from 2009 onwards by slightly raising the average compared to previous years results.

- In 2016 all results were recorded as is with decimal places, so geomeans will not be exactly comparable to previous years but as population levels are reported here, the differences are likely to be slight and the trends in blood lead levels will still be meaningful.

Age-sex Standardisation of Results

Children's blood lead levels vary by age and gender, hence, 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 variation. 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 to <5 years.

Data source

From 1991 through to the end of 2017, children's demographics, blood lead levels as well as environmental data, were stored on a standalone Access® database. This included data from children tested at Maari Ma Primary Health Care Service. With the ending of Access® software use by NSW Health, data from late 2017 was also loaded onto the Powerchart/CHOC application of the Electronic Medical Records from Cerner systems solutions. Maari Ma have continued to provide their blood lead screening data for loading on the CHOC application. From 2018 lead data was stored only on CHOC.

Appendix 1

The criteria for birthing in Broken Hill is that they have to be "low risk". The most recent revision of the capability of the Obstetric Birth Unit at Broken Hill allows for:

- Normal labour and birth care for women ≥37 weeks gestation.
- Induction of labour for women ≥38 weeks gestation.
- Vaginal birth after caesarean section for women ≥37 weeks gestation without medical induction or augmentation with oxytocin (Syntocinon®.)
- Antenatal and intrapartum continuous electronic fetal heart rate monitoring as a means of fetal welfare assessment when clinically indicated.
- Instrumental births when clinically indicated.
- Elective caesarean section ≥39 weeks gestation.
- Elective caesarean for DC/DA twins ≥37 weeks gestation.
- Emergency caesarean section when clinically indicated.
- BMI recommendation: Women with a BMI of ≥35 at the booking visit are referred to dietetic services and/or Get Health in Pregnancy services. If BMI is ≥ 46 at 36 weeks gestation, the woman is referred to Flinders Medical Centre for labour and birth management. All women with a BMI ≥35 at booking are informed of this possibility and documentation is made in the woman's antenatal risk assessment to reflect this.

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

- Less than 37 weeks gestation
- If BMI is ≥ 46 at 36 weeks gestation, the woman is referred to Flinders Medical Centre for labour and birth management
- 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.