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Lead Report Summary 2021:

Broken Hill children less than 5 years old

Broken Hill University
Department of Rural Health

NSW GOVERNMENT
Health
Far West
Local Health District

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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.

In September 2021 there was a product recall for the POCT LeadCare II test strips, used by both Child & Family Health Service and Maari Ma Aboriginal Health Corporation. This meant most testing of children aged 6 months and over effectively came to a halt mid September. For Child & Family none of the recalled test strip lots had been used while Maari Ma also had test strip lots not in the recall notice, so blood lead test results reported are not affected by the recall.

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 2021, there were 201 live births at Broken Hill Hospital (including by women who live elsewhere). Twelve babies, whose mothers lived elsewhere, had their cord blood tested. Of babies who had a Broken Hill address at birth or at their 6 month test and cord blood was taken for lead testing, 1 baby with clotted cord blood was excluded and 4 other babies were also excluded as there was no cord blood result so were likely not tested. In all 160 Broken Hill babies successful tests are reported.

The geometric mean of umbilical cord lead level was 0.7 µg/dL, in 2021 (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=128) were non-Aboriginal. All newborns, except a pair of twins, had blood lead levels below the notifiable level. At this age there is very little difference in geomeans between non-Aboriginal and Aboriginal infants (0.6 µg/dL v 0.8 µg/dL respectively).

Umbilical Cord Blood Lead Screening in Broken Hill newborns 1996-2021

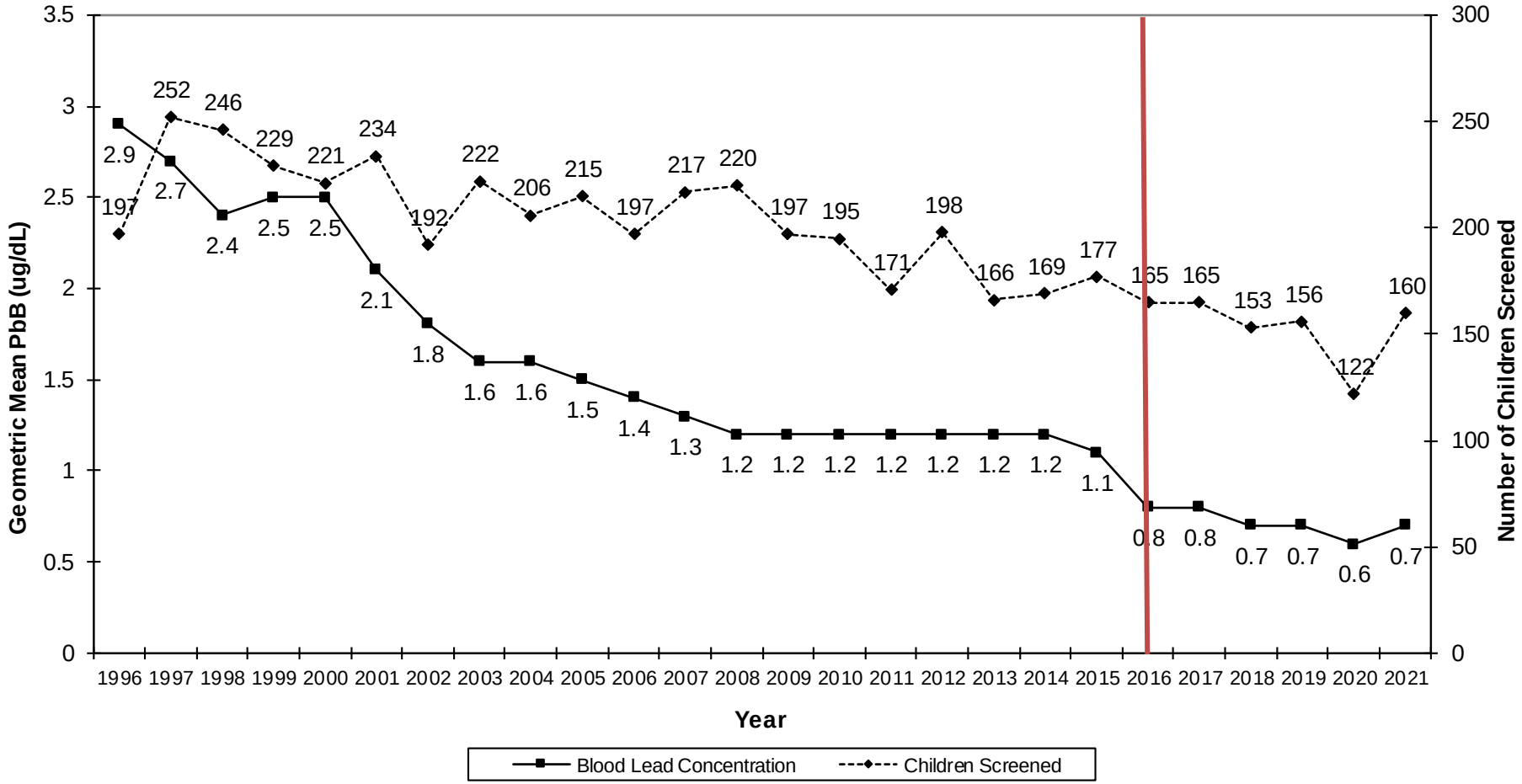

Figure 1. Geometric mean for cord blood lead (PbB) concentration and number of resident newborns screened at Broken Hill Health Service, 1996-2021. The vertical red line is indicative of the improvements made in the recording of results since 26th of April 2016. The geometric means collected since 2016 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 2021 a total of 160 children were tested with a geometric mean of 2.4 µg/dL (Figure 2), which was a decrease of 1.5 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 7% from 25% in the same period (Figure 3).

Of all children tested 76% (n=122) identified as non-Aboriginal. Non-Aboriginal children had a geomean of 2.3 µg/dL and Aboriginal children had a slightly higher geomean of 2.6 µg/dL.

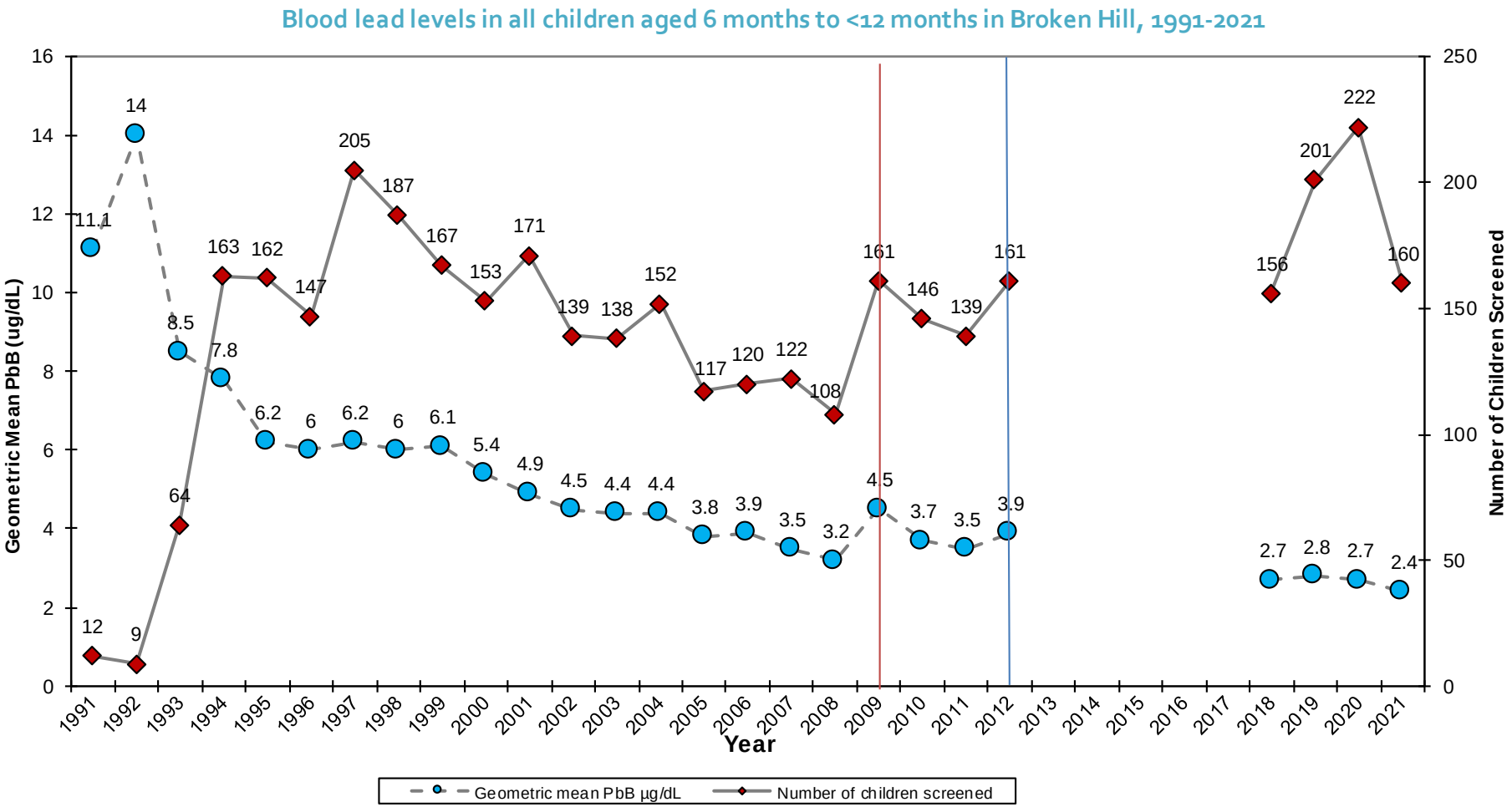

Figure 2. Geometric mean blood lead concentration and number of children screened aged 6 months to <12 months in Broken Hill, 1991-2021. The red vertical line indicates the point in which both venous and capillary samples are reported together and the blue vertical line indicates the point in which the 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.

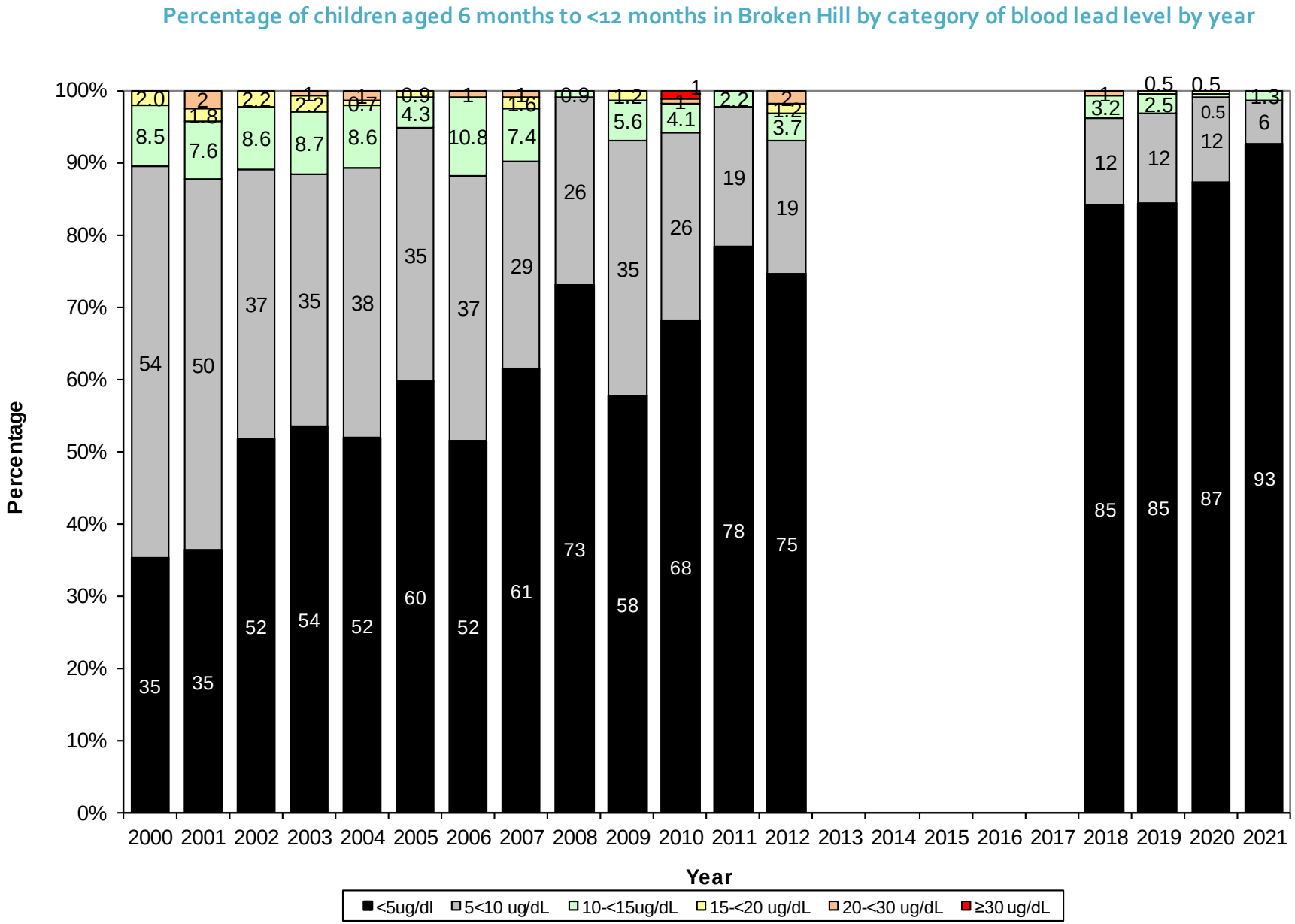

Figure 3. Percentage of Broken Hill children aged 6 months to <12 months in each blood lead category (2000-2021).

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 2021, a total of 561 children had at least one test, a decrease of 19% from children tested in 2020 due to recall of the POCT strips in mid-September and COVID restrictions however their geomean decreased to 3.6 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 68% in 2021, with Figure 5 and Table 1 showing that since 2012 the proportion fluctuated between 42-54% until 2021.

While the total number of children tested in 2021 decreased, the number of children in the <5 µg/dL category is greater than seen in previous years (Table 1). The proportion of children in categories above 5 decreased in 2021 compared to all previous years (Figure 5).

Table 1 Blood lead levels in all children aged 1 to <5years in Broken Hill, 2012-2021

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
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
2021	**561**	**3.6**	**392**	**68**

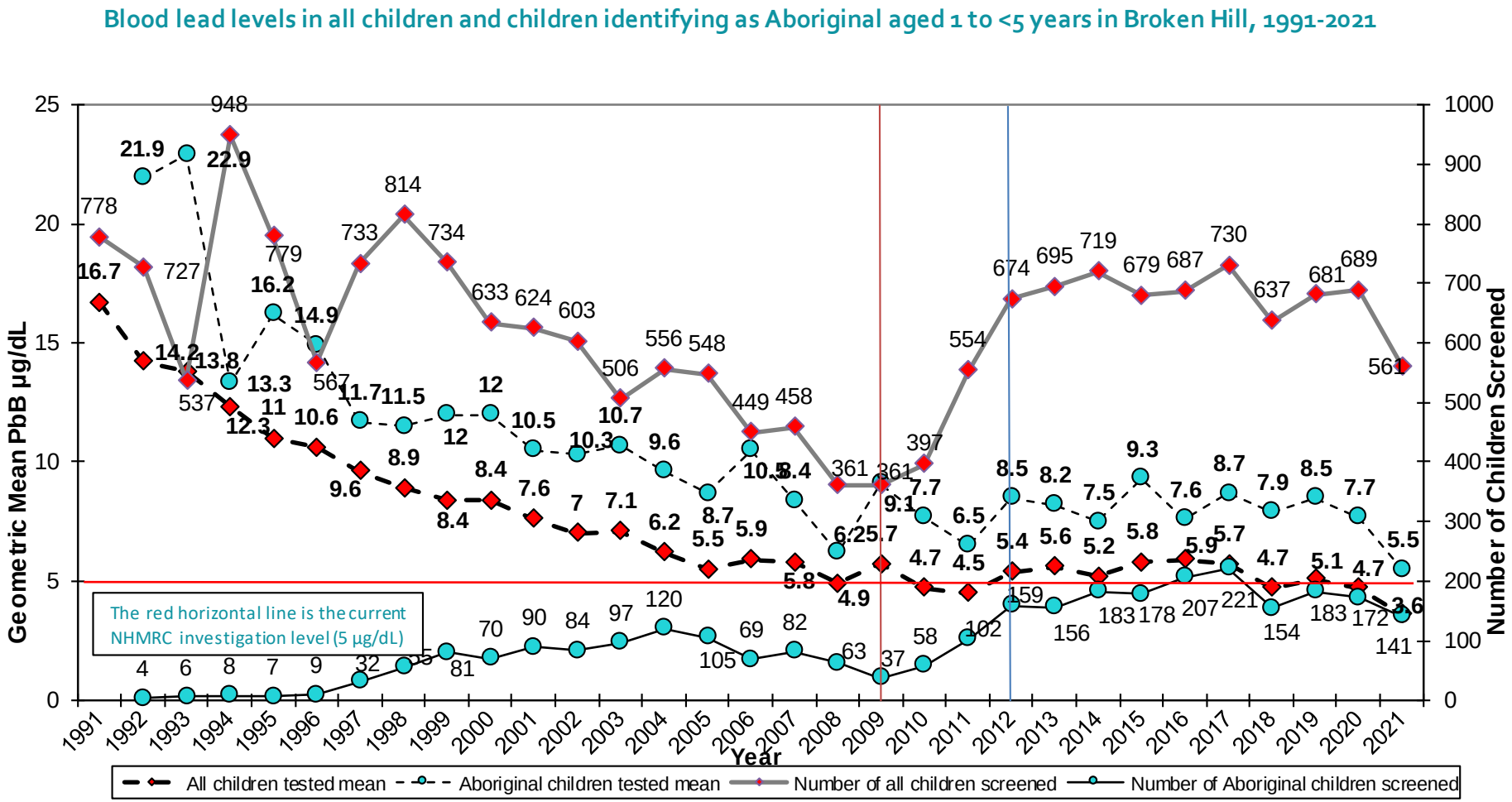

Figure 4. Population age-sex standardised geometric mean blood lead concentration and number of all children and Aboriginal* children screened aged between 1 to <5 years in Broken Hill, 1991-2021. 2009 was the year both venous and capillary samples were first reported together; 2011 the inclusion of 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.

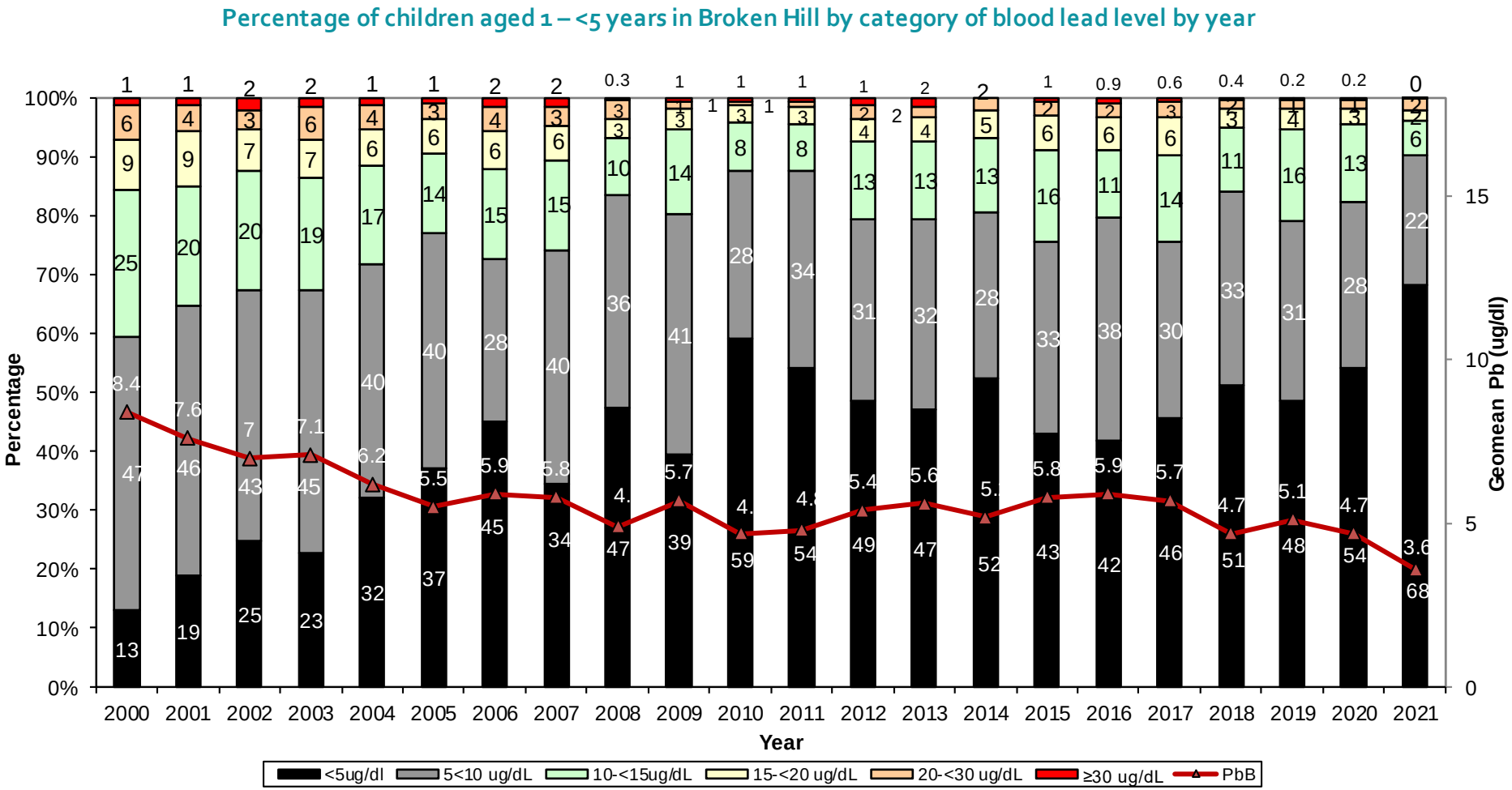

Figure 5. Age-sex standardised percentage of Broken Hill children aged 1 to <5 years in each blood lead category and population age sex standardised geometric mean (2000-2021).

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

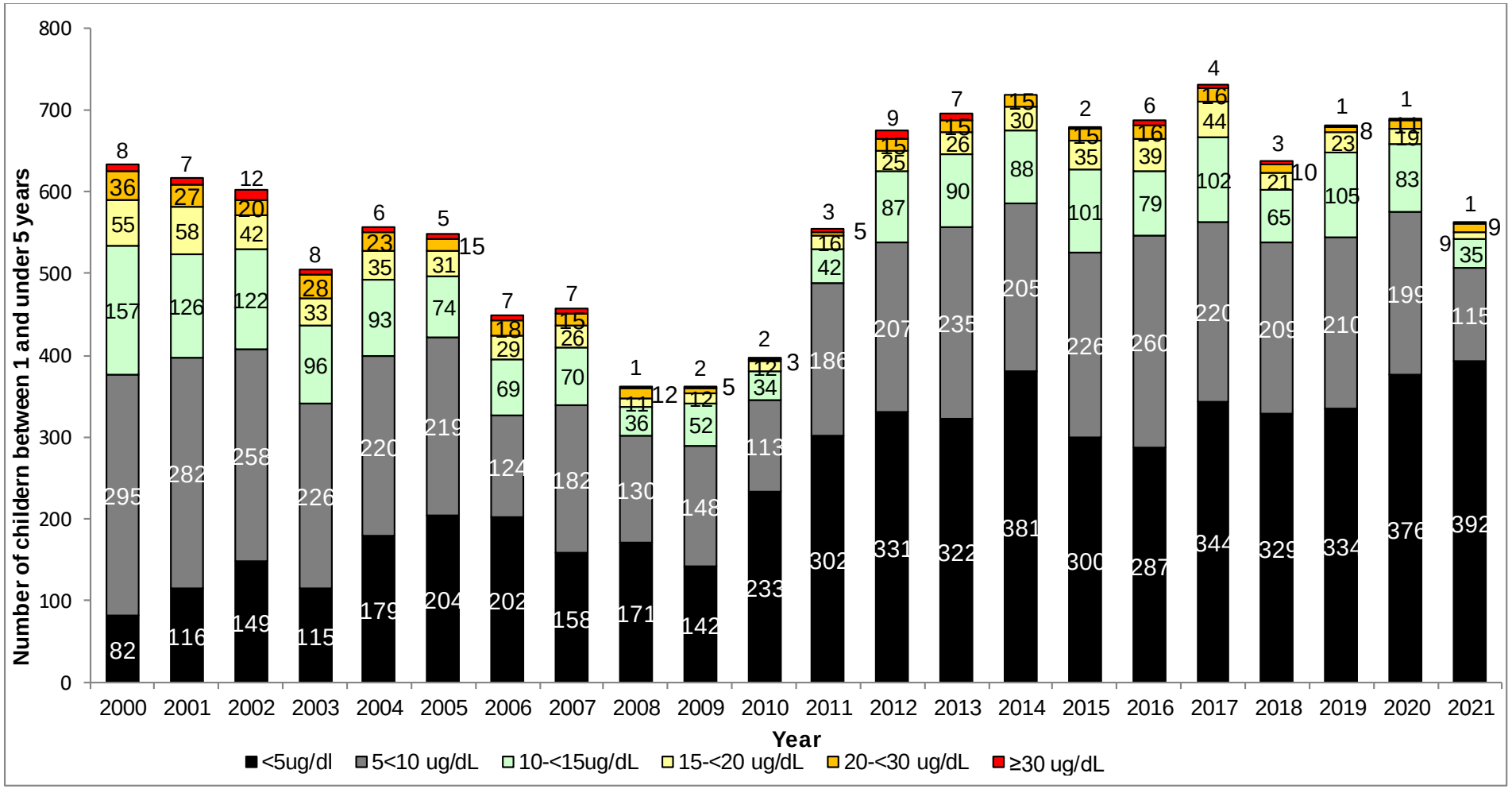

Figure 6. Count of all tested Broken Hill children in each blood lead category, aged between 1 to <5 years, 2000-2021.

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 2021, the number of Aboriginal children tested decreased 19% from 172 to 139. There was also a decrease in the Aboriginal age-sex standardised mean, from 7.7 µg/dL (2020) to 5.5 µg/dL in 2021 (Figure 4, Table 2). The gap between Aboriginal and non-Aboriginal children blood lead levels which had remained stable around 4.0 µg/dL since 2012 decreased to 2.4 µg/dL.

In 2021, 49% of tested Aboriginal children had a blood lead level less than 5 µg/dL, an increase from the 30% in 2020 and the proportions since aligning screening with immunization (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) – 49% compared to 77% (Aboriginal and non-Aboriginal respectively). In the years previous to 2020 the proportion of Aboriginal children <5 µg/dL averaged 22% while the average for the non-Aboriginal children was 58%, but the proportion of Aboriginal children <5 has more than doubled in 2021, while non-Aboriginal children <5 have increased by a third (Figure 8).

Table 2 Blood lead levels in Aboriginal and non-Aboriginal children aged 1 to <5 years in Broken Hill, 2012-2021

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
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
2021	**139**	**5.5**	**68**	**49**	**322**	**77**

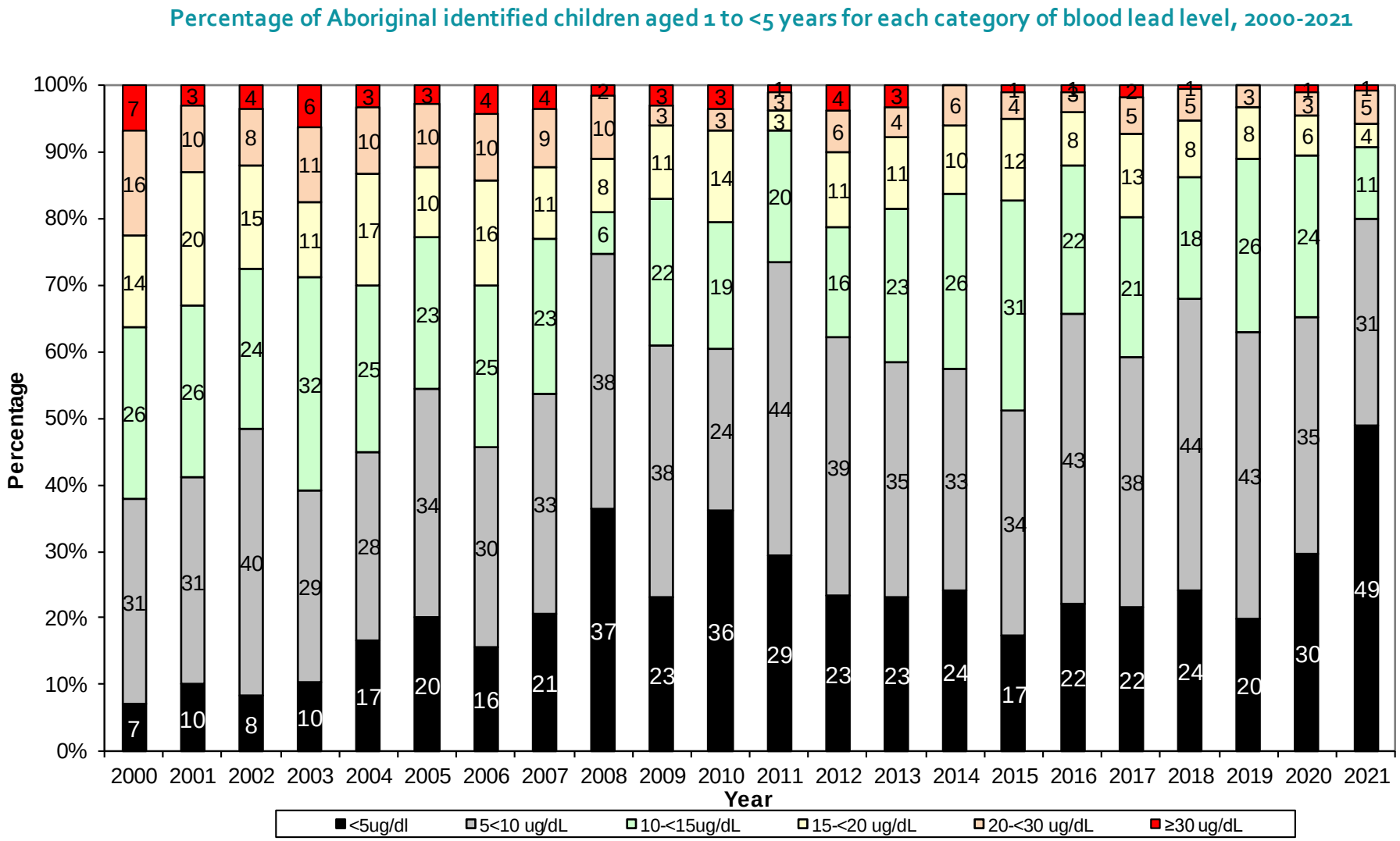

Figure 7. Percentage of Broken Hill Aboriginal children in each blood lead category, aged between 1 to < 5 years, 2000-2021. Data is presented from 2000 as before that the proportion and number of Aboriginal children tested was small, additionally caution should be used with the 2006 – 2010 results as 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, 2021

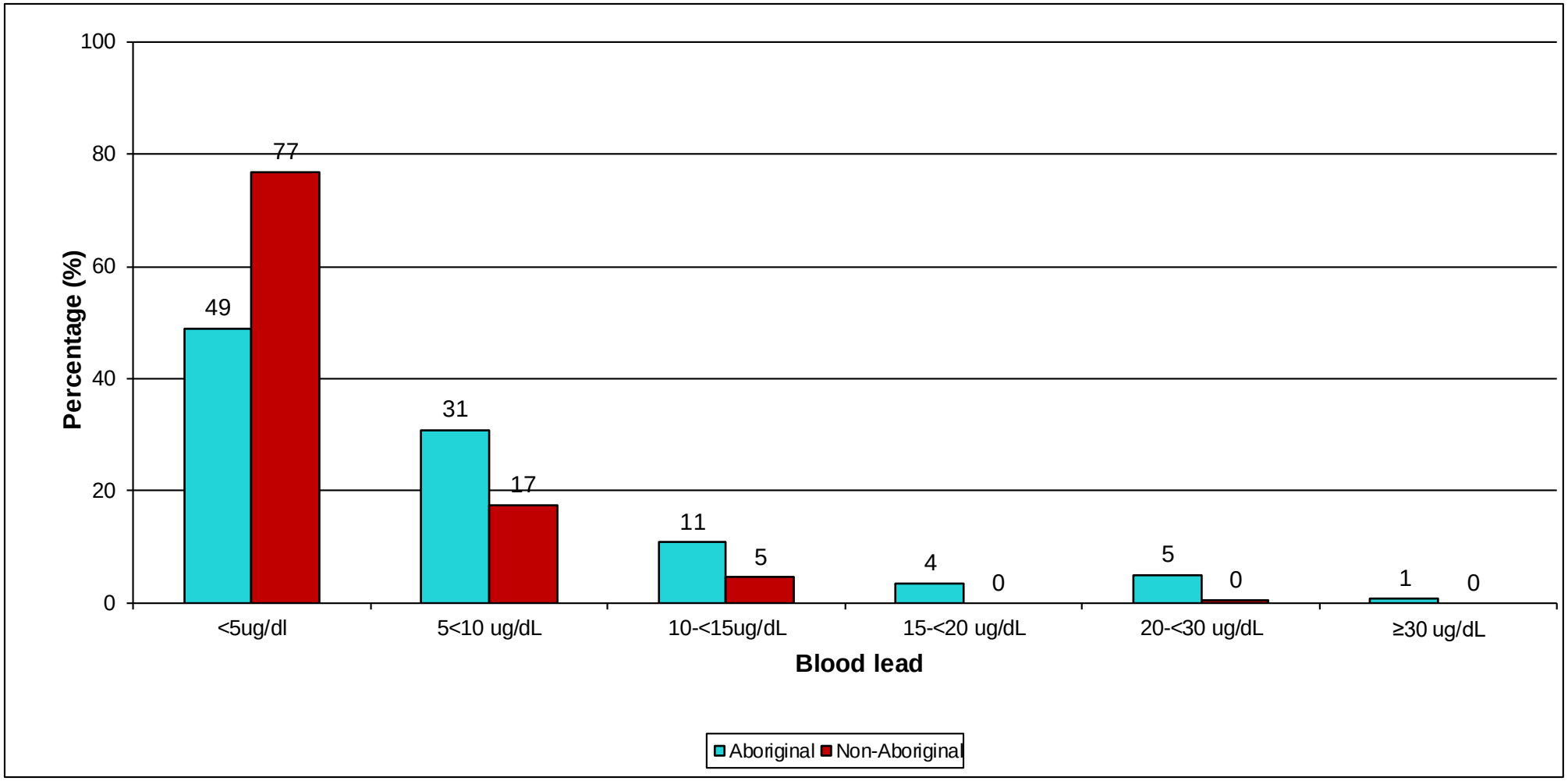

Figure 8. Comparison of Aboriginal versus non-Aboriginal aged 1 to <5 years by blood lead categories (2021).

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

Seasonal analysis has shown 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. The POCT strip recall in early September resulted in only 19 children tested (compared to 127 in 2020) between September – December. While these months are included in Figure 9 below, the geomeans reflect the small number of children tested, and are only reported for completeness.

While the number of children having their first test followed the pattern of previous years, the monthly geomeans for first three months in 2021 were noticeably lower than previous years, 2012 to 2020. April to August also had lower geomeans than previous years. More rain fell in 2021 than immediate past years 2017-2020 and with continuation of the COVID-19 emphasis on hand washing and hygiene both have contributed to lower 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 2021

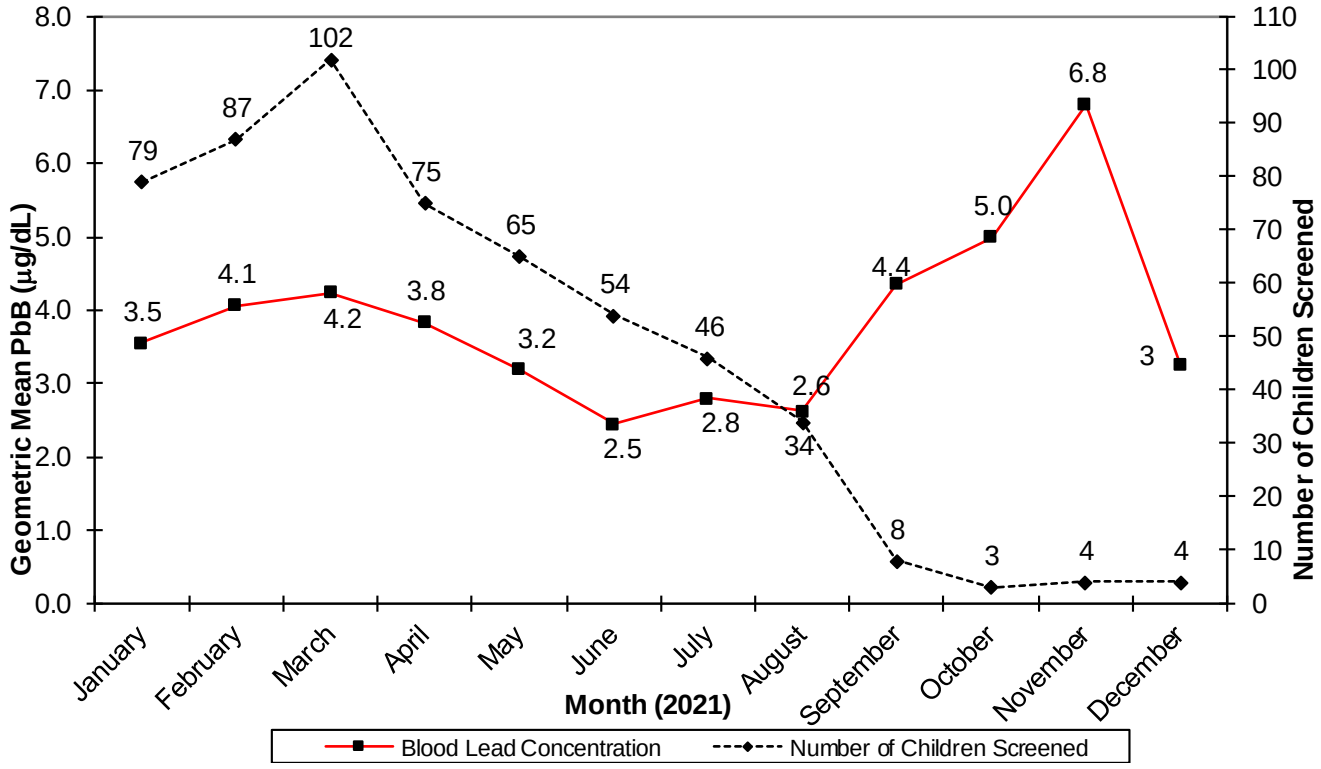

Figure 9. Monthly geometric mean blood lead level comparison of first visit blood lead levels for Broken Hill children aged between 1 to <5 years of age for 2021.

Conclusion

The Lead Testing Program performed well during 2021. Despite COVID-19 restrictions, testing numbers only declined in children aged 6 months and over with the POCT strip recall from September.

While population blood lead levels fluctuate from year to year, the underlying trend has been that levels have not changed significantly since 2012. However in 2021 less than half (32%) of the children aged 1 to <5 years and only 7% of children aged 6 months to < 12 months had a notifiable blood lead level (≥5 µg/dL). In 2021 newborns had a geomean of 0.7 µg/dL; children aged between 6 months to <12 months had a geomean of 2.4 µg/dL; and the age-sex standardized geometric mean for children aged 1 to <5 years was 3.6 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. This year, however, the discrepancy between the two groups has decreased, from hovering around 4 µg/dL since 2012, to 2.4 µg/dL. While Aboriginal children aged 1 to < 5 years were still twice as likely to have a notifiable blood lead level ≥5 µg/dL than non-Aboriginal children, for both the proportions had substantially decreased from 2020 (from 70% to 51% and from 37% to 23% respectively).

With COVID-19 lockdown restrictions from mid August the C&FHC decided to minimize client visits to only children presenting for immunization and/or yearly health check. Only these children would be then be offered lead testing. This may have affected screening attendances, but the number of children screened, before the POCT recall, would suggest otherwise. In 2020 parents reported that recommended COVID-19 preventative measures like hand hygiene, reinforced the behaviour for children as well as adults. COVID-19 restrictions in 2021 gave families time for home renovations and housecleaning, consequently asking C&FHC how to do these in a lead safe manner. Many aspects of the BHELP program, including dust monitoring, internal home remediation and testing of landscape supplies were stopped during the lockdown (18 August – 11 November), or curtailed (eg the indoor air HEPA filter study) in 2021.

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 2021 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.

In September 2021 there was a product recall for the POCT LeadCare II test strips, used by both Child & Family Health Service and Maari Ma Aboriginal Health Corporation. This meant most testing of children aged 6 months and over effectively came to a halt mid September, though Maari Ma also had test strips lots not in the recall notice. For Child & Family the recalled test strip lots were still unused, so blood lead test results reported are not affected by the recall.

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 data available (i.e. 2016, 2021 Census data will be released from June 2022). 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.