Lead Program Annual Report 2024:

Broken Hill children less than 5 years old

Acknowledgements

We acknowledge the traditional owners of country throughout the region. We pay respects to the people and their culture and to Elders past and present.

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Lead Program Annual Report 2024: Broken Hill children less than 5 years old, WNSW LHD Public Health Unit, Health Protection, June 2025

Table of Contents

Executive Summary

Background

Broken Hill is a town established around the mining of the world's largest deposit of lead, silver, and zinc, known as the 'Line of Lode'. The Line of Lode has been mined continuously for almost 140 years, resulting in ubiquitous lead in soil and dust throughout the town and surrounding areas. Lead is a naturally occurring element that can be harmful to the human body. Children aged under 5 years of age, in particular, are more likely to breathe in or ingest small amounts of lead-contaminated dirt or dust as they interact with their physical environment. They can absorb a higher proportion of lead than adults, as their smaller bodies are rapidly growing and developing and are therefore more at risk to the harmful effects of long-term lead exposure. It is well established that blood lead levels (BLLs) greater than 10 micrograms per decilitre (µg/dL) can have harmful effects on many organs and bodily functions. There is less conclusive evidence for the association of BLLs ranging from 5 µg/dL to less than 10 µg/dL with adverse cognition and behaviour, as well as other poor health outcomes. According to the National Health and Medical Research Council the average BLL in Australia is estimated to be less than 5 µg/dL.[1] In New South Wales (NSW), BLLs of 5 µg/dL and over are required to be notified to public health units. For the purposes of this document, 'guideline' refers to BLLs less than 5 µg/dL and is used as a proxy population-level benchmark to measure the impact of ongoing environmental and health service focused strategies aiming for all children in Broken Hill to maintain blood lead levels below the guideline.

Broken Hill Lead Program

The Broken Hill Lead Program (the Program) aims to undertake BLL screening of resident children aged under 5 years, aligning this with their immunisation schedule or health check appointments. Blood lead testing is voluntary and offered free of charge to parents and carers through the Far West Local Health District (FWLHD) Broken Hill Child and Family Health Service (CFHS) and the Maari Ma Health Aboriginal Corporation's (MMHAC) Maari Ma Primary Health Care Service (MMPHCS). Children attending the CFHS are screened every 6 months commencing from 6 months, while children attending the MMPHCS are screened every 6 months commencing from 12 months of age[a] until the age of 2 years. From the age of 2 years, children attending both services are screened annually until 5 years of age. Screening of umbilical cord BLLs of newborns, born to Broken Hill resident mothers, is also included in the Program.

The Program has evolved over time to monitor children's BLLs as they interact with their physical environment across three developmental stages, through which children go from being completely dependent to being physically independent. The *Lead Program Annual Reports* historically present trends in BLLs for screening of children, according to these three stages of development: newborns, 6 months to less than 12 months of age and 1 year to less than 5 years of age. As a child may undergo multiple blood lead tests in the same year, the first BLL is used for analyses for each of the three categories.

The *Lead Program Annual Report 2024* presents trends over time of BLL screening for newborns and children aged 1 year to less than 5 years from 2015. Since systematic screening of all resident

[a] *Since 2018, continuous first point of care testing lead screening from 6 months was offered systematically by both services. Commencing in January 2024, following a detailed internal review, the Maari Ma Health Aboriginal Corporation modified their program delivery model and began implementing first point of care testing lead screening at 12 months of age rather than at 6 months of age. The Broken Hill Child and Family Health Service continue to offer first point of care testing lead screening from 6 months of age.*

children aged 6 months to less than 12 months is no longer conducted, comparing trends with previous years is not appropriate. Analyses of BLL screening for this cohort are presented in Appendix 1. Reports summarising data from the commencement of the Program in 1991 are available on request.

Results

Newborns, 2015 to 2024

In 2024, umbilical cord blood from 141 newborns of Broken Hill resident mothers were tested for BLLs. Of these newborns, 28% (n=39) are Aboriginal and 72% (n=102) are non-Aboriginal. Of the 141 umbilical cord bloods screened:

- 100% had BLLs within the guideline (less than 5 µg/dL).
- The geometric mean of all BLLs was 0.6 µg/dL.

There was no difference between the geometric mean of BLLs for Aboriginal newborns compared to that for non-Aboriginal newborns.

While the rates of annual participation ranged from a low of 73% to a high of 90% over the 10-year reporting period, the proportion of newborns screened for BLLs in 2015 and 2024 was identical, i.e., 90%. Over the 9 years of comparable results, from 2016 to 2024, the annual geometric mean declined, from 0.8 µg/dL to 0.6 µg/dL respectively.

Children aged 6 months to less than 12 months, 2024

In 2024 there were 162 children screened aged from 6 months to less than 12 months. Of these children:

- 10% (n=16) had BLLs above the guideline, including 12 with BLLs within the range of 5 to less than 10 µg/dL and 4 with BLLs within the range of 10 to less than 15 µg/dL.
- The geometric mean of all BLLs was 2.5 µg/dL.

Children aged 1 year to less than 5 years, 2015 to 2024

In 2024, there were 719 children aged 1 year to less than 5 years screened for BLLs. Of these children:

- 26% (n=186) were Aboriginal and 74% (n=530) were non-Aboriginal, with less than 1% (n=3) having no record for this indicator.
- Using the ABS 2021 Census population count for Broken Hill Local Government Area (LGA) resident children aged 1 to less than 5 years as the denominator for standardizing the program participation to the general population for this cohort, the estimated participation rate in the Program for all children was 92%.
- Participation rates increased across all age groups compared to 2023, with the exception of the 3-year-olds which remained steady at 63%.
- 68% of Aboriginal children screened had BLLs above the guideline compared to 35% of non-Aboriginal children screened.
- 6% of Aboriginal children screened had high or very high BLLs (≥20 µg/dL) compared to 1% of non-Aboriginal children.

Applying the age-sex standardised calculations to the Broken Hill ABS 2021 population for children aged 1 year to less than 5 years, the annual geometric mean was 4.3 µg/dL, which is below the guideline. Nonetheless, the age-sex standardised percentage of children in this cohort with BLLs

above the guideline was 43% which equates to 337 children. Stratification by one-year age groups reveals that 1-and 2-year-olds had the equal highest proportions of children with BLLs above the guideline (47%).

Over the 10-year period from 2015 to 2024, the number of screened children aged 1 year to less than 5 years increased by 6%, from 679 to 719, respectively. The average annual estimated participation rate over that time equated to 85%. As such, the 2024 rate of 92% is above the reporting period average, continuing the increasing trend in participation since the impact of COVID-19 in 2021.

From 2015 to 2024, the annual age-sex standardised geometric mean for all children in this age group fell by 1.5 µg/dL i.e., from 5.8 µg/dL (above the guideline) to 4.3 µg/dL (below the guideline) respectively, and the percentage of children with BLLs above the guideline decreased from 57% to 43%, respectively. Importantly, the statistically significant decrease in unadjusted geometric means resulting in no overlap of the 95% confidence intervals with the guideline that occurred for the first time in 2021, has been sustained in preceding years occurring again in 2024, i.e. 4.2 µg/dL (95% CI: 3.93:4.57).

The annual age-sex standardised geometric mean for Aboriginal children in 2024 of 6.6 µg/dL remains above the guideline. From 2015 to 2024, the annual age-sex standardised geometric mean for Aboriginal children fell by 29%, from 9.3 µg/dL to 6.6 µg/dL respectively. However, the disparity between the annual age-sex standardized geometric mean for Aboriginal children compared to non-Aboriginal children in this cohort remains largely unchanged over time. In 2024 the geometric mean for Aboriginal children was 1.8 times higher than for non-Aboriginal children compared to 2.0 times higher in 2018.

A decrease in the percentage of Aboriginal children with BLLs above the guideline over the 10-year reporting period from 83% to 68%, respectively, is noted. However, there remains a significant gap in the proportion of BLLs above the guideline for Aboriginal and non-Aboriginal children in this cohort. The average annual percentage over this reporting period for Aboriginal children with BLLs above the guideline was 72%, double that for non-Aboriginal children (36%).

Seasonal trends, 2024

In 2024, the quarters with the higher geometric means correlated with the warmer months. There was no correlation for the quarters with the higher rainfalls or testing numbers.

Conclusion

Over the reporting period, participation rates in the Program decreased marginally for the screening of newborns while those for children aged 1 to less than 5 years were the highest since 2017. The annual BLL geometric mean for 2024 was unchanged for the cord blood screening and well below the guideline. Changes to the age at which screening commences for children attending MMPHCS means that trend comparisons for the 6 to less than 12 months cohort are not possible. In 2024, the annual geometric mean for the 6 to less than 12 months age cohort screened was below the guideline. While 10% of this age cohort had BLLs above the guideline, all were less than 15 µg/dL. It is important to note, however, that these comparisons are not reflective of the resident cohort. For children aged 1 year to less than 5 years screened, there was a slight decrease in standardised geometric mean compared to 2023, and the unadjusted geometric mean for 2024 remains significantly below the guideline. Importantly, the annual standardised geometric mean for Aboriginal children in this age cohort remains above the guideline and was 1.8 times higher than that for non-Aboriginal children.

Background

Broken Hill is a town located in the far west of New South Wales (NSW) and experiences the hot, dry, and windy climate associated with this region. It was founded in 1883 following the discovery of the world's largest deposit of lead-silver-zinc. The ore body known as the 'Line-of-Lode', has been mined continuously since 1884, and the city has grown out around this.[2] Onsite smelting activities and waste management practices in the early years of mining and the impact of wind and water erosion on lead-contaminated sites has resulted in the ubiquitous distribution and concentration of lead in soil and dust throughout the city.

Consequently, Broken Hill residents, miners, industry workers and their families experience long term environmental lead exposure. Changes to mining practices, including underground extraction, off-site smelting, capping of waste dumps along the Line of Lode, storm water control on the mining leases and waste disposal regulation, have seen a large reduction in atmospheric lead emissions over time.[3] However, ore continues to be brought to the surface for processing and concentration, so mining emissions are an ongoing issue.[4] Furthermore, the predicted climate changes for Far West NSW forecasting an increase in temperatures and decrease in rainfall over the 20 years from 2020 to 2039 will potentially increase the frequency of dust storms, soil dispersion and therefore elevate lead dust loading into the environment.[5]

Lead is a naturally occurring element found in a variety of compounds and remains in the earth until physically removed through mining. As a result of long-term mining and widespread industry use including house paint and petroleum, lead can be found throughout the Australian environment.[5] People absorb lead into the body by ingesting or breathing in lead-contaminated dust. As such, most people have some level of lead in their system. The average 'background' blood lead level (BLL) is estimated to be less than 5 micrograms per decilitre (µg/dL).

The effect of lead exposure on health varies according to age, dose, and length of exposure. The ill-health risk for children and babies (including in utero) exposed to lead is higher than in adults, because their bodies are smaller, and their bodies and brains are growing and developing at a rapid rate.[1] Children are more likely to breathe in or ingest lead-contaminated dust and dirt as they explore and physically interact with their environment and frequently touch their mouths. Lead toxicity can affect a range of molecular processes, partly due to its ability to inhibit and mimic the actions of calcium. This in turn impacts the function of many organs and systems within the body.

It is well established that BLLs greater than 10 µg/dL can lead to adverse effects on digestive, cardiovascular, renal, reproductive, and neurological functions.[6] However, the evidence for a causal link between BLLs of 5 to 10 µg/dL is less clear, despite the identification of potential associations with adverse cognitive effects and behavioural problems in children, delays in sexual maturation in adolescents and increased blood pressure in adults. Currently, BLLs equal to or above 5 µg/dL are notifiable under the 2016 Public Health Amendment to the NSW Public Health Act 2010.[7] For the purposes of this report, 'guideline' will refer to BLLs less than 5 µg/dL.

Broken Hill Lead Program

A 1991-1993 survey of Broken Hill children aged from 1 year to less than 5 years of age found that 86% of these children had BLLs of 10µg/dL or above and that 38% had very high lead levels of 20µg/dL or above.[8] Following these findings, a targeted program designed to monitor BLLs in children aged under 5 years of age in Broken Hill was instituted.[9] Between 1991 and 2012, the age-sex standardized geometric mean blood lead level reduced by about two-thirds (from 16.7 µg/dL to 4.5 µg/dL) and has since ranged between 5.6 – 4.3 µg/dL during 2013-2024.[10]

The Broken Hill Lead Program (the Program) has evolved over time to collect blood lead samples from three groups of children aged less than 5 years, based on the developmental progression of children from being completely dependent to being physically independent, and include[11]:

1. Newborns, whose umbilical cord blood is tested at birth to determine the impact of lead transfer from the mother to the child and is considered a proxy baseline for the child.
2. Children aged 6 months to less than 12 months, who are learning to explore their environment by putting objects into their mouths and have limited mobility through crawling but may be restrained outside.
3. Children aged from 1 year to less than 5 years, who are moving towards independence and can more freely interact with their environment, often with decreasing hand to mouth play and increasing autonomy with activities such as handwashing.

Comparisons of BLLs across the groups inform both intervention needs and monitoring of the Program. Program participation is free of charge and voluntary, and screening is aligned with the immunisation schedule so that children are tested at 6 months, 12 months, 18 months, and 2 years and then at 3 years and again at 4 years. The Program is promoted via reminder phone text messaging to parents and carers, promotions, and advertising through local media. If BLLs are found to be above the guideline, children are recalled for repeat testing and appropriate clinical management and treatment.

NB: From January 2024 Maari Ma Health Aboriginal Corporation (MMHAC) began implementing first point of care lead screening at 12 months of age rather than from 6 months of age. This followed a review of historical screening data and NSW Environmental Protection Authority (EPA)-led Broken Hill Environmental Lead Program implementation, and consultation with NSW Health and NSW EPA. The rationale behind the change in the screening schedule was that normal developmental mobility and hand to mouth behaviour would not typically place a child of 6 months of age at risk of significant lead exposure. The number of children screened at 6 months since 2015 at Maari Ma Primary Health Care Service (MMPHCS) with a recorded blood lead level >10ug/dL was <1 per year. The current capacity of the NSW Government home remediation program means that the overwhelming majority of 6-month-olds would not qualify for home remediation. Screening this cohort without being able to offer intervention does not meet the criteria in the Australian Population Based Health Screening Framework. MMPHCS continues to provide age-appropriate one-to-one education to all families of 6-month-olds about reducing lead exposure risk in this cohort. The service additionally conducts risk-based screening of any child, including those younger than 12 months, on a case-by-case basis, including those children with siblings who record elevated BLLs, children residing in homes with known high lead risk, and on parent/carer/guardian request. This decision will be reassessed should evidence for a need for earlier screening emerge, or if there is increased program funding to ensure that these children are eligible to receive meaningful intervention to address lead exposure risk.

Broken Hill Local Government Area Population Profile

The Australian Bureau of Statistics (ABS) census population data for the years since the commencement of Broken Hill Lead Program (1996, 2001, 2006, 2011, 2016 and 2021) has shown a decline in both the number and the proportion of children under the age of 5 years residing in the Broken Hill Local Government Area, overall and for each of the 1 year age groups (Table 1).[12] Analysis of BLLs for annual reporting is stratified by Aboriginality to monitor any inequitable burden in high BLLs which may exist. Counts of the Aboriginal children population are sourced from the Census data and so are reliant on self-identification. The number of Aboriginal children aged under 5 years has increased by 71% from 1996 to 2021. Conversely, over the same period, the number of all Broken Hill children aged under 5 years has decreased by 31%.

Table 1: ABS Usual Resident Population 0-4 years from 1996 to 2021, total population and stratified by age and Aboriginality, 1996 to 2021

Census Year	1996	2001	2006	2011	2016	2021	1996-2021 % change
All children 0-4 years	1,403	1,297	1,184	1070	977	972	-31%
(% of total population)	(6.6%)	(6.4%)	(6.1%)	(5.8%)	(5.5%)	(5.5%)	
Children aged 0 years	247	236	228	186	196	192	-22%
(% of total population)	(1.2%)	(1.2%)	(1.2%)	(1.0%)	(1.1%)	(1.1%)	
Children aged 1 year	280	247	222	230	189	186	-36%
(% of total population)	(1.3%)	(1.2%)	(1.1%)	(1.2%)	(1.1%)	(1.1%)	
Children aged 2 years	282	250	227	236	183	205	-27%
(% of total population)	(1.3%)	(1.2%)	(1.2%)	(1.3%)	(1.0%0	(1.2%)	
Children aged 3 years	306	280	228	197	217	175	-43%
(% of total population)	(1.4%)	(1.4%)	(1.2%)	(1.1%)	(1.2%)	(1.0%)	
Children aged 4 years	288	284	279	221	196	218	-24%
(% of total population)	(1.3%)	(1.4%)	(1.4%)	(1.2%)	(1.1%)	(1.2%)	
Aboriginal children 0-4 years	112	165	177	176	182	191	71%
(% of 0-4yr population)	(8.0%)	(13.0%)	(17.0%)	(16.0%)	(19.0%)	(20.0%)	

Source: Australian Bureau of Statistics, Usual Resident Population, Census and Housing.

Methods

Collection of blood samples

For newborn babies born at the Broken Hill Health Service (BHHS), an umbilical cord blood sample is taken for laboratory testing. BLLs for children less than 5 years are taken as either a finger prick (capillary) or venous test (considered more invasive). Since blood lead screening is aligned with the childhood immunisation schedule, testing may occur at 6 months, 12 months, 18 months, and 4 years of age. Children aged 2 and 3 years of age are encouraged to be presented for testing to ensure each child is monitored at least once every year until they turn 5 years old.

Data collation and analysis of blood lead levels

Where a child has had multiple BLL tests in the same calendar year, only the first test for the year is used for analysis. Exceptions to this include situations where a child is tested at age 6 months to less than 12 months and then turns 1 in the same year; they will be included in the analysis twice i.e., in the 6 months to less than 12 months cohort and then in the 1 year to less than 5-year cohort. Where a venous test and capillary test have been collected in the same calendar year for a child, the venous test, considered to be a more accurate test, is included in the analysis over the capillary test(s).

The geometric mean, as opposed to an average or arithmetic mean, is used to report BLLs. This is because the majority of children have lower BLLs, and only a small number have very high levels. The arithmetic mean is strongly affected by the very high values whereas the geometric mean normalises the values being averaged so that no value dominates the weighting.[13]

Up until 2016, all blood lead results were rounded up or down when recorded in the database. The reason for this practice is unclear but may have been related to the capabilities of the original Access® database. From 2016, all results were recorded with decimal places, so geometric means will not be exactly comparable to previous years. This particularly affects low results such as those recorded for cord blood analysis. Also, the minimum reading possible for capillary sampling is 3µg/dL compared to <1µg/dL for venous sampling. A "low result" reading is also possible for capillary testing and is recorded as 2 µg /dL. This affects the geometric means by slightly raising the average compared to those for the years where capillary testing was not available (before 2009). During 2022 and 2023, there were three brief time periods where a recall or ruptures in the supply of the LeadCare II analyser's Point of Care testing strips disrupted on-site testing, impacting the two testing sites differently.[b] A different testing method was used when the Point of Care strips were unavailable, so its lower cut off level may have also affected the geometric mean during that period. However, as population levels are reported here, the impact of the testing and resulting differences are likely to be slight and the trends in BLLs will still be meaningful. There were no disruptions to the supply of testing strips in 2024.

Age-sex standardisation of results

Children's BLLs can vary by age and gender, hence, it is difficult to compare BLLs from year to year unless the same proportion of children in each age group is tested for the successive years. Therefore age-sex standardisation is used to account for this variation. Effectively, this

[b] Offsite testing was used by one testing site for 3 months from the end of January to the end of April 2022 and then for 5 weeks during July to September 2023.

determines what the BLL 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. This age-sex adjusted or standardised population mean is reported for children aged 1 year to less than 5 years. Unadjusted means with 95% confidence intervals (2015 to 2024) are available in Appendix 2.

Data source

Until 2017, all children's demographics and BLLs were stored on a standalone Access® database. NSW Health ceased using Access® software and all data was loaded onto the new platform, the Powerchart/Community Health Outpatient Care (CHOC) application of the Electronic Medical Records from Cerner Systems Solutions. MMHAC have continued to provide their blood lead screening results for loading onto the CHOC application.

Results

Screening of umbilical cord blood of newborns, 2015 to 2024

Newborns screened

In 2024 there were 172 live births at the BHHS, 157 of which were identified as belonging to Broken Hill and the immediate surrounds (postcode 2880) resident mothers[c]. In this same year, umbilical cord blood lead screening was completed on 141 newborns of Broken Hill resident mothers, which equates to a participation rate of 90% for cord blood lead screening in 2024.

Of the 141 newborns tested, 28% (n=39) identified as Aboriginal and/or Torres Strait Islander and 72% (n=102) were non-Aboriginal. While the rates of annual participation ranged from a low of 73% to a high of 90% over the 10-year reporting period, the proportion of newborns screened for BLLs in 2015 and 2024 was identical, i.e., 90%. (Table 2).

Table 2: Annual total of Broken Hill newborns screened and annual total of live births for 2015-2024, with the percentage of newborns screened given as a proportion of the total live births.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
No. of newborns screened	177	165	165	153	156	122	160	157	152	141
No. of live births	196	209	188	176	185	166	201	203	184	157
% Newborns screened	90%	79%	88%	87%	84%	73%	80%	77%	83%	90%

Blood lead levels

All of the 141 newborn cord bloods tested in 2024 had BLLs within the guideline (<5 µg/dL). Overall, this equated to an annual geometric mean of 0.6 µg/dL equal to that for the years from 2022 onwards (0.6 µg/dL). Due to a change in the recording of BLLs from 2016, comparisons to annual geometric means prior to 2016 is not appropriate (see Methods section for more information). As such, looking at the trend from 2016 to 2024, annual geometric means have decreased overall, from 0.8 µg/dL to 0.6 µg/dL respectively (Figure 1). This decrease in geometric mean is concurrent with an 18% decline in the number of live births at the BHHS since 2016 (Table 2).

There was no difference in geometric means for Aboriginal and non-Aboriginal newborns in 2024.

[c] The number of live births and postcode residence of mothers for 2024 was obtained from the manager of Maternity and Newborn Services at the Broken Hill Base Hospital.

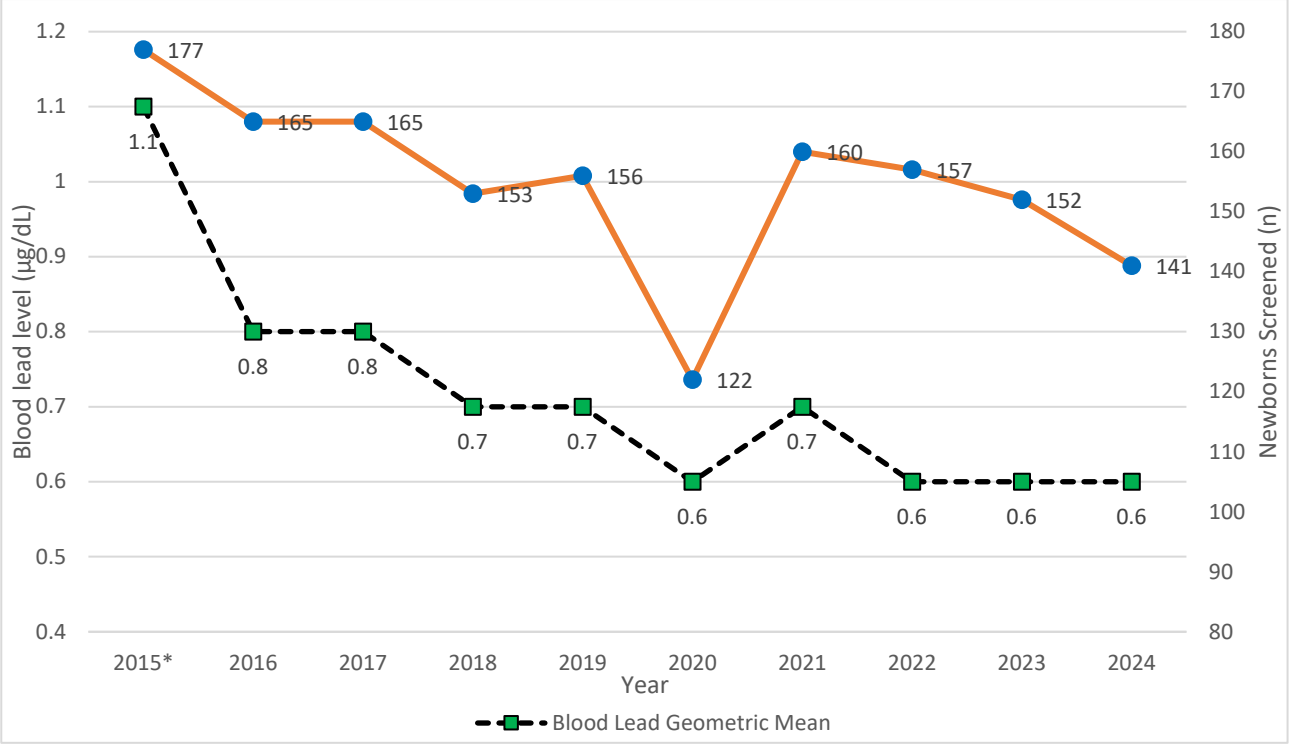

*Figure 1: Annual total of Broken Hill newborns screened and annual blood lead level geometric mean, 2015-2024. *Prior to 2016, BLLs were rounded up or down which particularly affects low results. As such the 2015 geometric mean is not comparable to those from 2016 onwards where decimal points were recorded.*

Screening of children aged 1 year to less than 5 years, 2015 to 2024

Children screened

In 2024 there were 719 children screened, a slight increase in the number of children screened from 2023 (n=711). Over the 10-year reporting period from 2015 to 2024, there was a 6% increase in the number of screened children aged 1 year to less than 5 years, from 679 to 719, respectively. Following the drop in screening in 2021 due in part to the pandemic and testing kit supply issues, screening numbers have steadily increased[d].

Of the 719 children screened, 26% (n=186) were Aboriginal and 74% (n=530) were non-Aboriginal, with less than 1% (n=3) having no record for this indicator. From 2015 to 2024 the number of Aboriginal children screened for BLLs increased by 4%, from 178 to 186, respectively (Figure 2), while the number of non-Aboriginal children screened (including those children where there was no record for this indicator) increased by 6%, from 501 to 533 respectively.

[d] Following a 18% decline in the number of children screened in 2021, participation increased by 17% in 2022. This is suggestive of a COVID19 pandemic artefact on the Program participation, due to reduced testing carried out from 13th September 2021 to 24th January 2022.

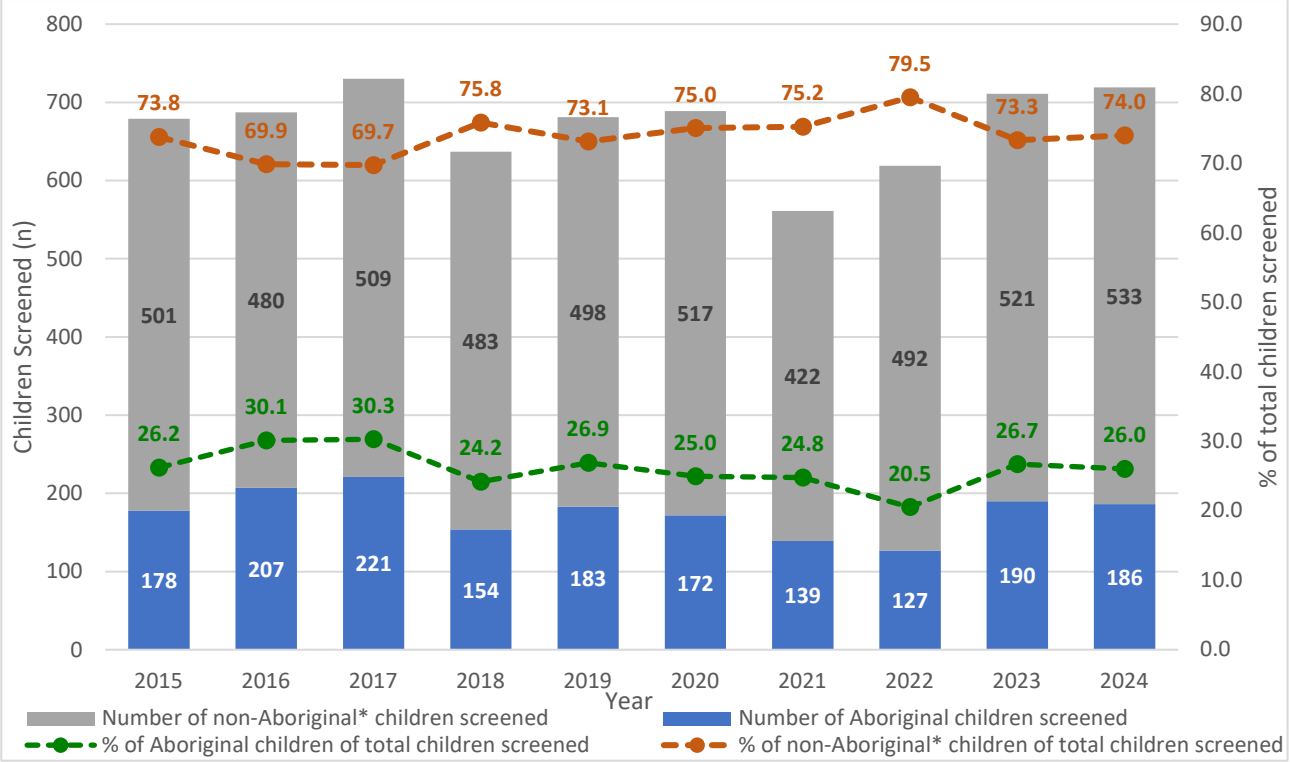

*Figure 2: Total annual number of children aged 1 year to less than 5 years screened for blood lead levels during 2015 to 2024, shown as numbers of Aboriginal and non-Aboriginal children screened, with the proportion of the total number of children screened by Aboriginal and non-Aboriginal status in percentage. *Non-Aboriginal screened include those children where this indicator was not recorded.*

Estimated participation rate

Participation rates are based on the population by age counts from the ABS 2021 census data as compared to the number of children screened.[e] The participation rate of all children aged 1 year to less than 5 years for 2024 was 92%, slightly higher than that for 2023 (Figure 3). Looking at the trends in participation for this age group over time, there was a 19% relative increase seen from 2015 to 2024, rising from 77% to 92% respectively, with the 10-year average annual participation rate equating to 85%.

The estimated participation rate for Aboriginal children aged 1 year to less than 5 years has fluctuated over the past 10 years and frequently exceeded 100%. While the under reporting of Aboriginality in the Census has improved over time, the 2016 and 2021 counts are less than the total Aboriginal children tested in Broken Hill for the years 2015 to 2017, 2019 to 2020 and 2023 to 2024. Consequently, a 10-year average rate was not calculated and participation rates for years 2018, 2021 and 2022 must be used with caution.

[e] Participation rates should be interpreted with caution due to data limitations with using the most recent ABS Usual Resident Population (URP) as total population or denominator. This is not ideal as census requires a minimum residency period to be counted as a resident, but in Broken Hill the mining related workforce (and family) can ebb and flow depending on ore prices and Aboriginal families may be more transient in their movements between extended family.

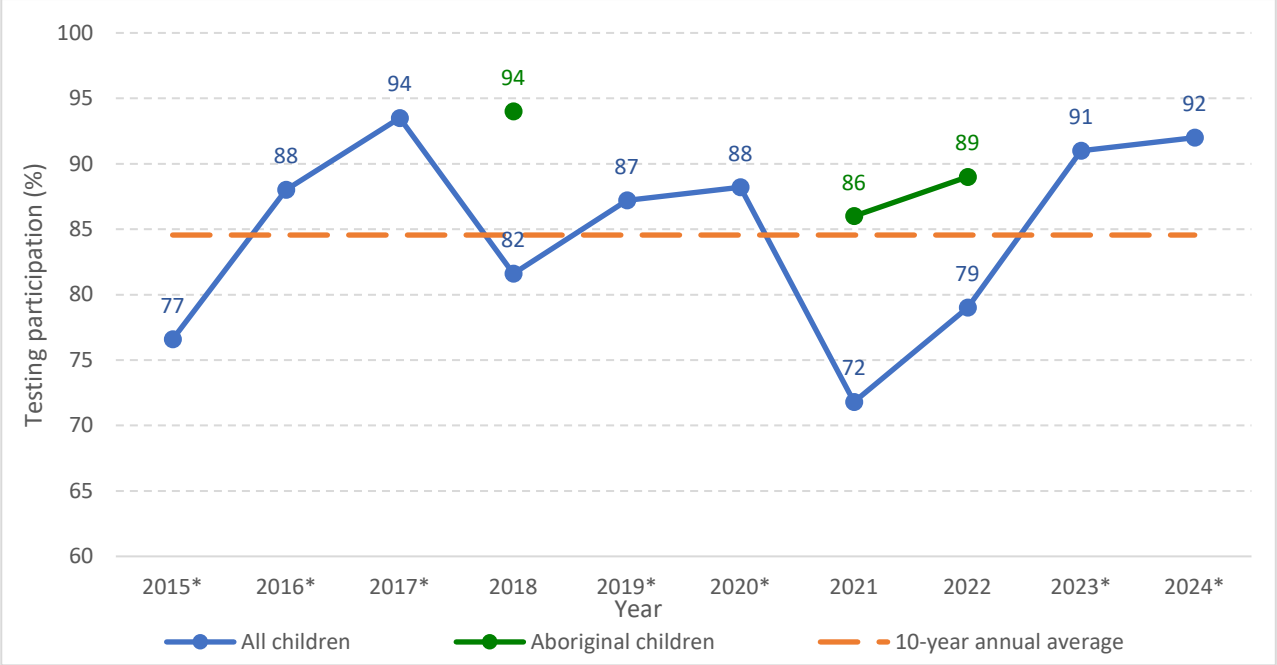

*Figure 3: Annual lead screening participation rate for all Broken Hill children and Aboriginal children aged between 1 and less than 5 years old, 2015-2024. *Participation rate for Aboriginal children exceeded 100%.*

Stratified participation rates

Stratifying the annual participation rate by 1 year age groups for 2018 to 2024 demonstrates the fluctuation in participation across the 2-, 3- and 4-year-old age groups. The generalised decline for all age groups in 2021 is again suggestive of the COVID-19 pandemic's impact (Table 3). However, since 2022, there has been an increase in participation across the age groups, with the exception of the 2-year-olds which only began to improve in 2023. The proportion of 1 year old children screened each year has consistently been above 100%.[f] In 2024, the participation rate for the 2-year-old and 4-year-old age groups increased, with relative rises of 19% and 7% respectively, while remaining steady for 3-year-olds at 63%. As blood lead testing is aligned with the childhood immunisation schedule, the lower participation for the 2- and 3-year-olds may be influenced by there being no scheduled vaccinations on the National Childhood Immunisation Program for these two age groups.

[f] Preliminary investigations into the reason for this increase in the participation rate for 1-year olds did not reveal any definitive conclusions, other than that previously outlined in terms of the limitation of using the most recent ABS Usual Resident Population (URP) as total population or denominator in the Broken Hill context.

Table 3: Annual lead screening participation rate for all Broken Hill children aged between 1 and less than 5 years old, 2018-2024, stratified by age group.

Year	1 year	2 years	3 years	4 years	All 1-4 years
2018	131%	75%	53%	76%	83%
2019	134%	72%	55%	86%	87%
2020	154%	61%	57%	82%	74%
2021	126%	51%	49%	66%	72%
2022	139%	40%	63%	70%	79%
2023	175%	54%	63%	75%	91%
2024	**165%**	**64%**	**63%**	**80%**	**92%**

Blood lead geometric means

All children

In 2024, the annual age-sex standardised BLL geometric mean[g] for children aged from 1 year to less than 5 years was 4.3 µg/dL, lower than that for 2023 (4.4 µg/dL) (Figure 4). [h] Over the 10 years from 2015 to 2024 the standardised BLL geometric mean decreased by 1.5 µg/dL, from being above the guideline at 5.8 µg/dL to below the guideline at 4.3 µg/dL. In 2021, the standardised geometric mean for this age group decreased to a record low of 3.6 µg/dL, which corresponded to a record low number of children screened that year and the different method of testing used during the last four months of that year.

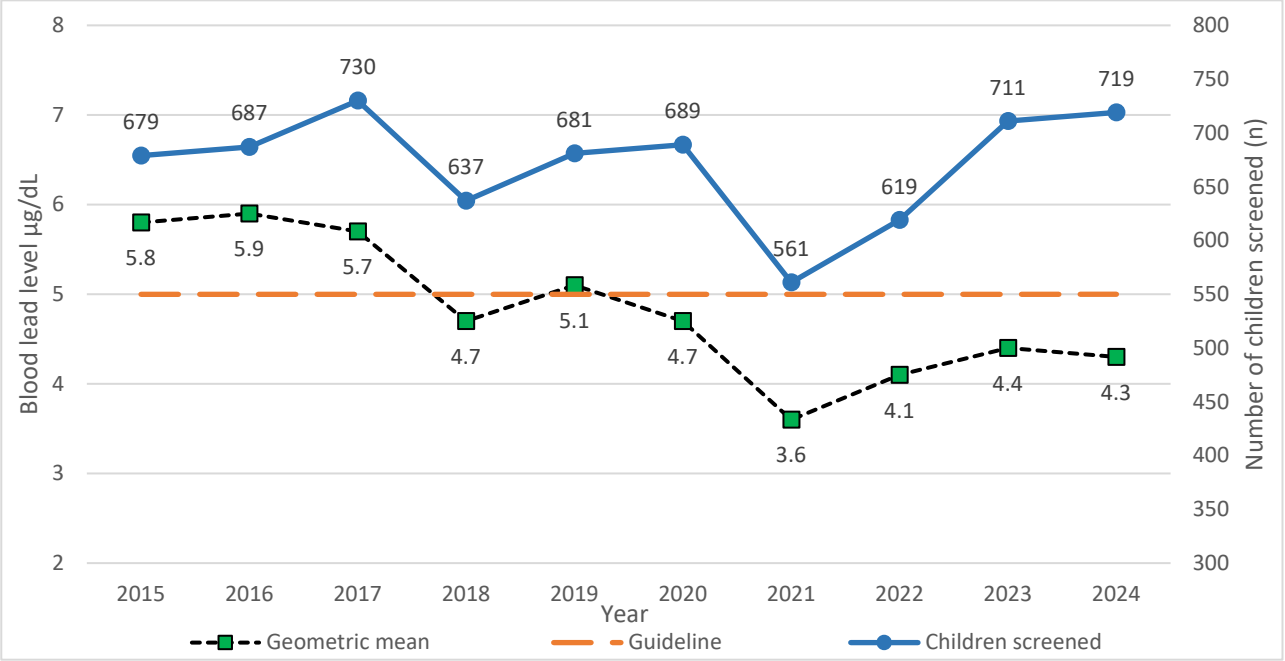

Figure 4: Annual number of Broken Hill children screened aged 1 to less than 5 years and population age-sex standardised geometric mean blood lead level compared to the NSW Health recommended guideline (<5.0 µg/dL), 2015 to 2024.

[g] See Appendix 2 for Unadjusted geometric means plus 95% confidence intervals and age-sex standardised geometric means for all children aged 1 to <5years in Broken Hill, 2015-2024.

[h] The lower cut-off level of the alternate testing method, used from the end of January to the end of April 2022 and then for 5 weeks during July to September 2023, may have influenced the geometric mean during these times. Although the small number of test results at the lower level during those periods would suggest that the overall effect would likely be minimal.

Aboriginal children

The 2024 annual age-sex standardised blood lead geometric mean of 6.6 µg/dL for Aboriginal children aged 1 year to less than 5 years was above the guideline, but 16% (1.3 µg/dL) lower than that for 2023. The standardised geometric mean for this population group from 2015 to 2024 decreased by 29% (2.7 µg/dL), from 9.3 µg/dL to 6.6 µg/dL, respectively (Figure 5).

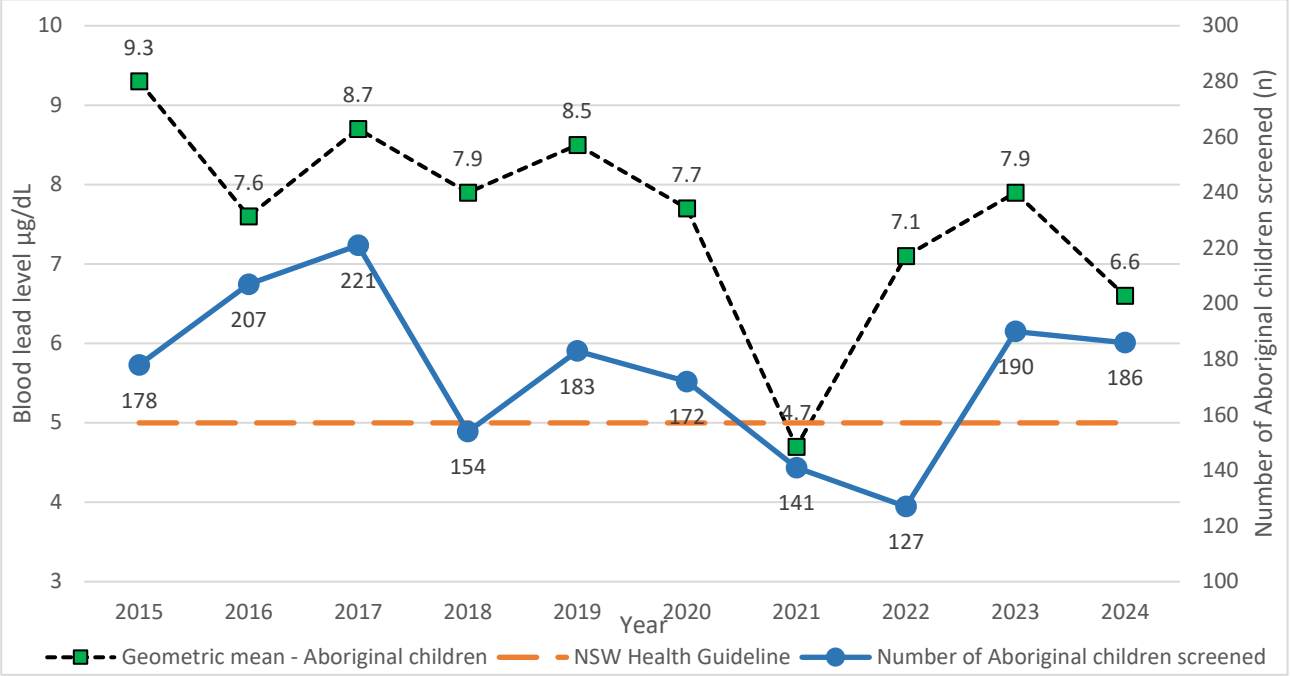

Figure 5: Annual number of Broken Hill Aboriginal children aged 1 to less than 5 years screened and the Aboriginal population age-sex standardised geometric mean blood lead level compared to the NSW Health recommended guideline (<5.0 µg/dL), 2015 to 2024.

Aboriginal children compared to non-Aboriginal children, 2018 to 2024

Figure 6 compares the annual age-sex standardised geometric means and ratios for Aboriginal children and non-Aboriginal children aged 1 to less than 5 years from 2018[i] to 2024. In 2024, the geometric mean for Aboriginal children was 1.8 times higher than that for non-Aboriginal children (6.6 vs 3.6 µg/dL). While the disparity between the geometric means for Aboriginal children and non-Aboriginal children in this cohort remains largely unchanged being on average of 1.9 times higher over the reporting period, there has been a slight downward trend from a ratio of 2.0 in 2018 to a ratio of 1.8 in 2024.

i The blood lead screening data for years prior to 2018 is held in an archived database and not accessible for analysis.

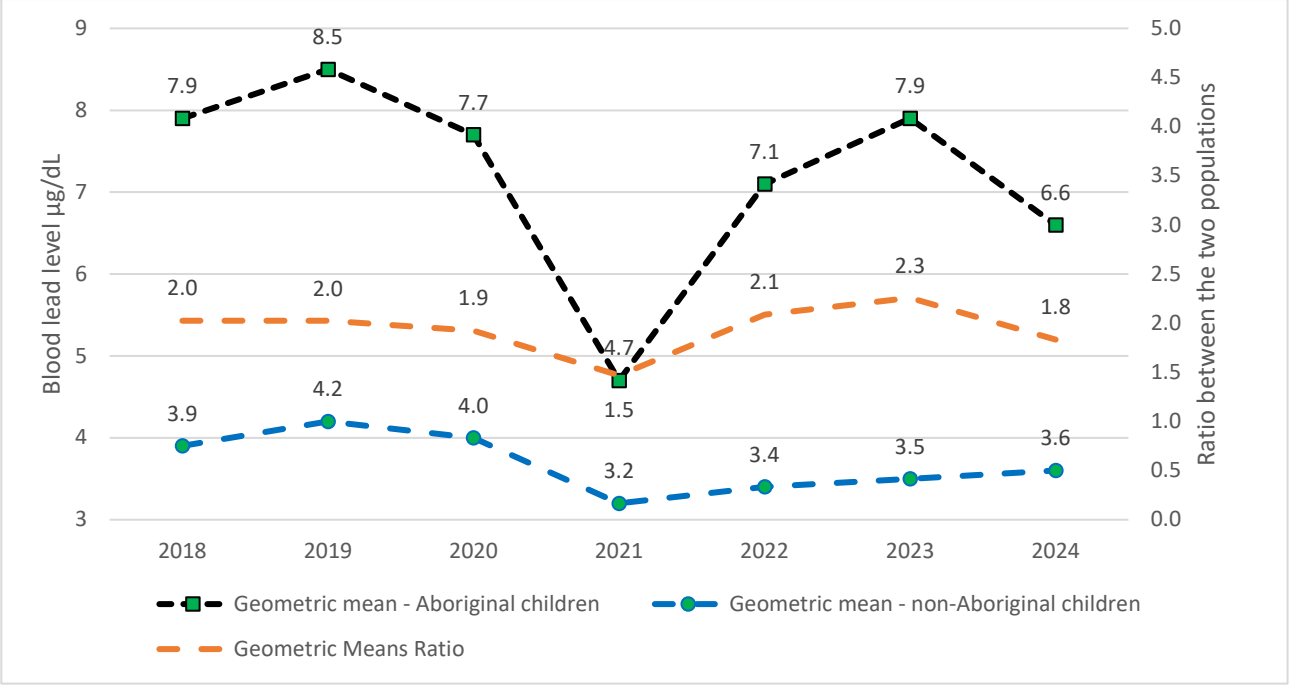

Figure 6: Age-sex standardised geometric means blood lead level and ratios for Aboriginal children and non-Aboriginal children aged 1 to less than 5 years), 2018 to 2024.

Stratifying age-sex standardised geometric means by age-group

Stratifying the 2024 population age-sex standardised geometric mean by 1 year age groups demonstrates that the geometric means for all age groups were below the guideline (Figure 7); highest in 2-year-old children, followed by 1- then 4-year-olds, and the lowest level in the 3-year-olds. Since 2019, the 2-year-old age group has consistently had the highest annual geometric mean levels of all age groups in this cohort.[j] The geometric mean for all year groups have been below the guideline since 2018, with the exception of 2-year-olds in both 2019 and 2020, and 3- and 4-year-olds in 2019.

[j] The blood lead screening data for years prior to 2018 is held in an archived database and not accessible to evaluate by 1-year groups prior to 2018 and provide further information about the change in pattern between 2018 and 2019.

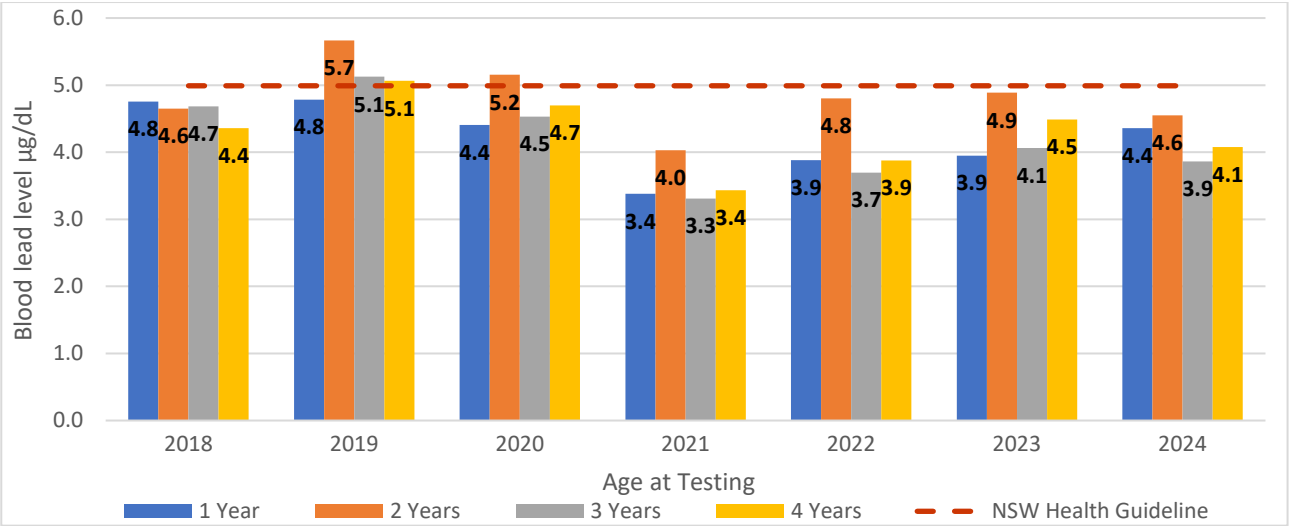

Figure 7: Annual population age-sex standardised geometric mean blood lead level for children screened aged 1 to less than 5 years, stratified by 1 year age groups and compared to the NSW Health recommended guideline (<5.0 µg/dL), 2018 to 2024.

Elevated blood lead levels

In 2024, the age-sex standardised percentage of all children aged from 1 year to less than 5 years with BLLs above the guideline was 43%, which equates to 337 children, based on the 2021 ABS census data, steady from 2023. The proportion of Aboriginal children aged from 1 year to less than 5 years with BLLs above the guideline was 68%, a decline from that in 2023 (74%).

From 2015 to 2024, the age-sex standardised percentage of all children aged 1 year to less than 5 years screened with BLLs above the guideline has decreased, from 57% to 43%, respectively. As such, over this 10-year reporting period, there has been a decrease in the percentage of children with BLLs ranging from 5 to less than 10 µg/dL, ,10 to less than 15 µg/dL, and 15 to less than 20 µg/dL (Figure 8). The percentage of children with levels ranging from 20 to less than 30 µg/dL remained unchanged (2%) with less than 1% having levels 30 µg/dL or above. Overall, this indicates that very high BLLs in this age group persist for a small number of children.

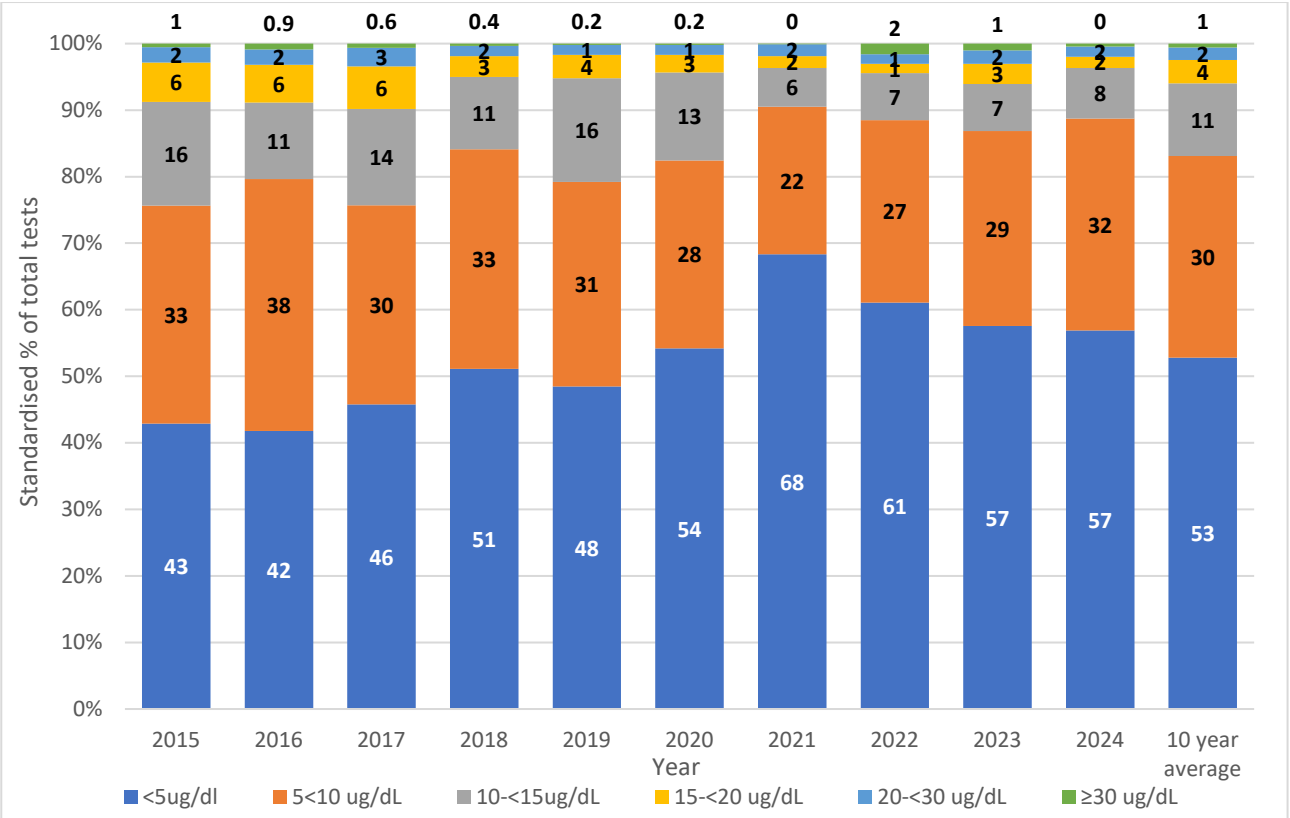

Figure 8: Blood lead levels of all children aged 1 to less than 5 year by category as a percentage of total annual tests, (age-sex standardised percentage), Broken Hill, 2015-2024. NB: totals may vary due to rounding.

Over the same reporting period (2015 to 2024), a comparison of the annual proportions of BLLs above the guideline between Aboriginal and non-Aboriginal children aged 1 years to less than 5 years evidences the disproportionality that exists between these populations (Figure 9). The 10-year average proportion of children with BLLs above the guidelines was 72% for Aboriginal children, in contrast to 35% for non-Aboriginal children in this age group. Nonetheless, the percentage of Aboriginal children screened with BLLs above the guideline has decreased, from 83% in 2015 to 68% in 2024. Over this period, the percentage of Aboriginal children with BLLs ranging from 5 to less than 10 µg/dL has increased (from 34% to 42%), but the percentage with BLLs from 10 to less than 15 µg/dL has decreased (from 31% to 16%). Importantly, the proportion of Aboriginal children with very high BLLs, 30 µg/dL or higher, has increased slightly from 1% (n=2) in 2015 to 2% (n=3) in 2024, while demonstrating a decline from concerningly high levels seen in 2023 (n=7).

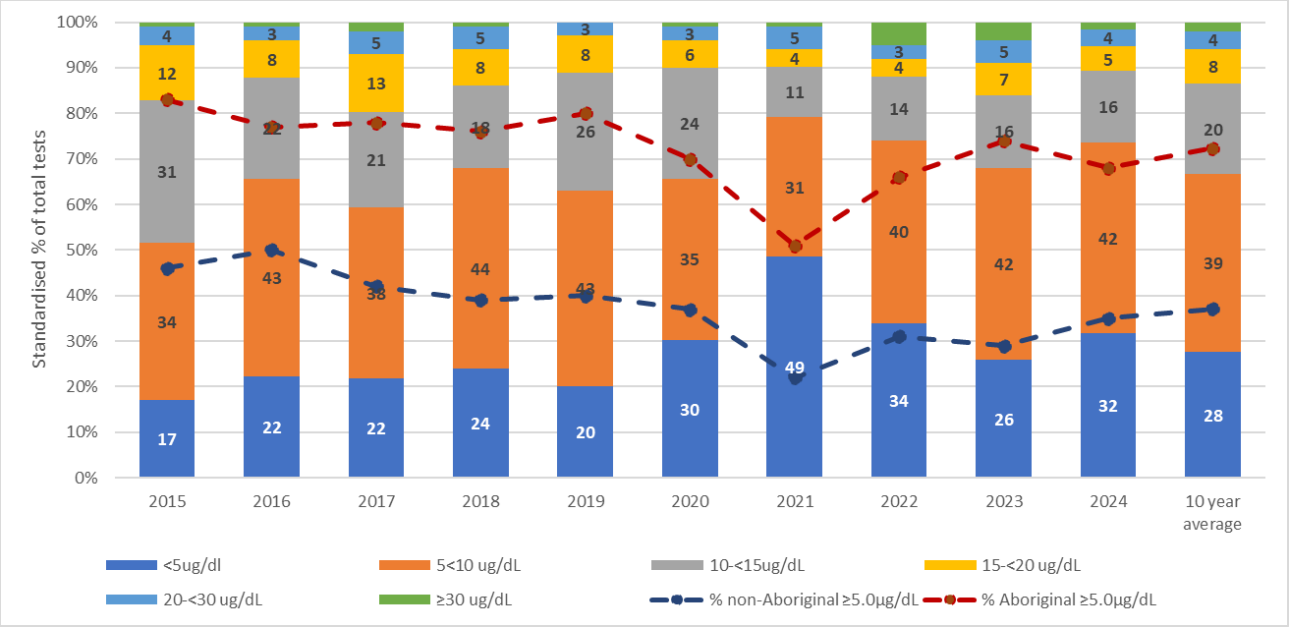

Figure 9: Blood lead levels of Aboriginal children aged 1 to less than 5 years by category as a percentage of total annual tests, with the annual proportions (%) of children testing over the NSW Health guideline (≥5.0 µg/dL) for non-Aboriginal and Aboriginal children, Broken Hill, 2015-2024. NB: totals may vary due to rounding.

In 2024, the age-sex adjusted proportion of Aboriginal children aged 1 to less than 5 years with BLLs below the guideline were less than half that for non-Aboriginal people, i.e., 32% compared to 65% (Figure 10). For all other categories where BLLs were above the guideline, the proportions for Aboriginal children were greater than those for non-Aboriginal children. In particular, 6% of Aboriginal children (n= 10 children) were found to have high or very high BLLs (≥20 µg/dL) compared to 1% of non-Aboriginal children (n= 3 child).

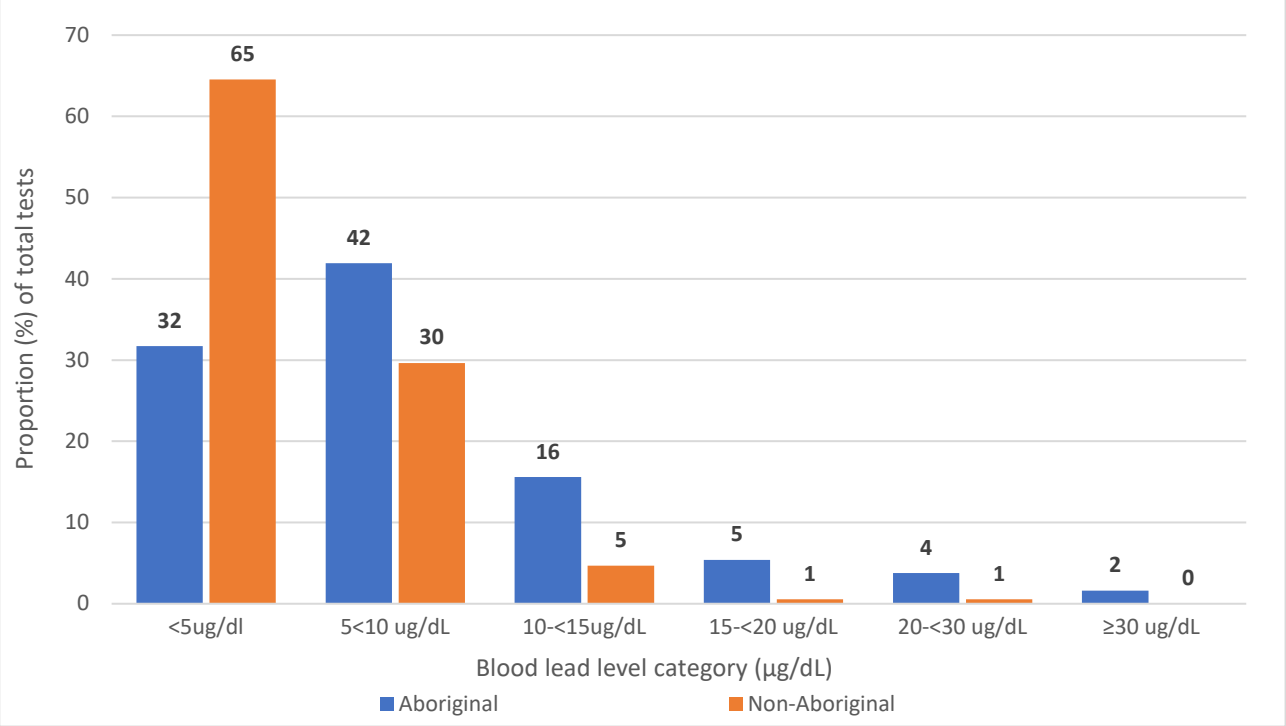

Figure 10: Comparison of Aboriginal versus non-Aboriginal children aged 1 to less than 5 years, stratified by blood lead category percentage, 2024.

Stratifying the 2024 age-sex standardised percentages of all children aged 1 year to less than 5 years by 1 year age groups reveals that 1- and 2-year-olds have the highest proportion (47%) of children screened with BLLs above the guideline (Figure 11). This is consistent with the higher geometric mean recorded for this year group in 2024 (Figure 7). The proportion of children with high (20-<30 µg/dL) or very high BLLs (30 µg/dL) was highest in 2-year-old age group.

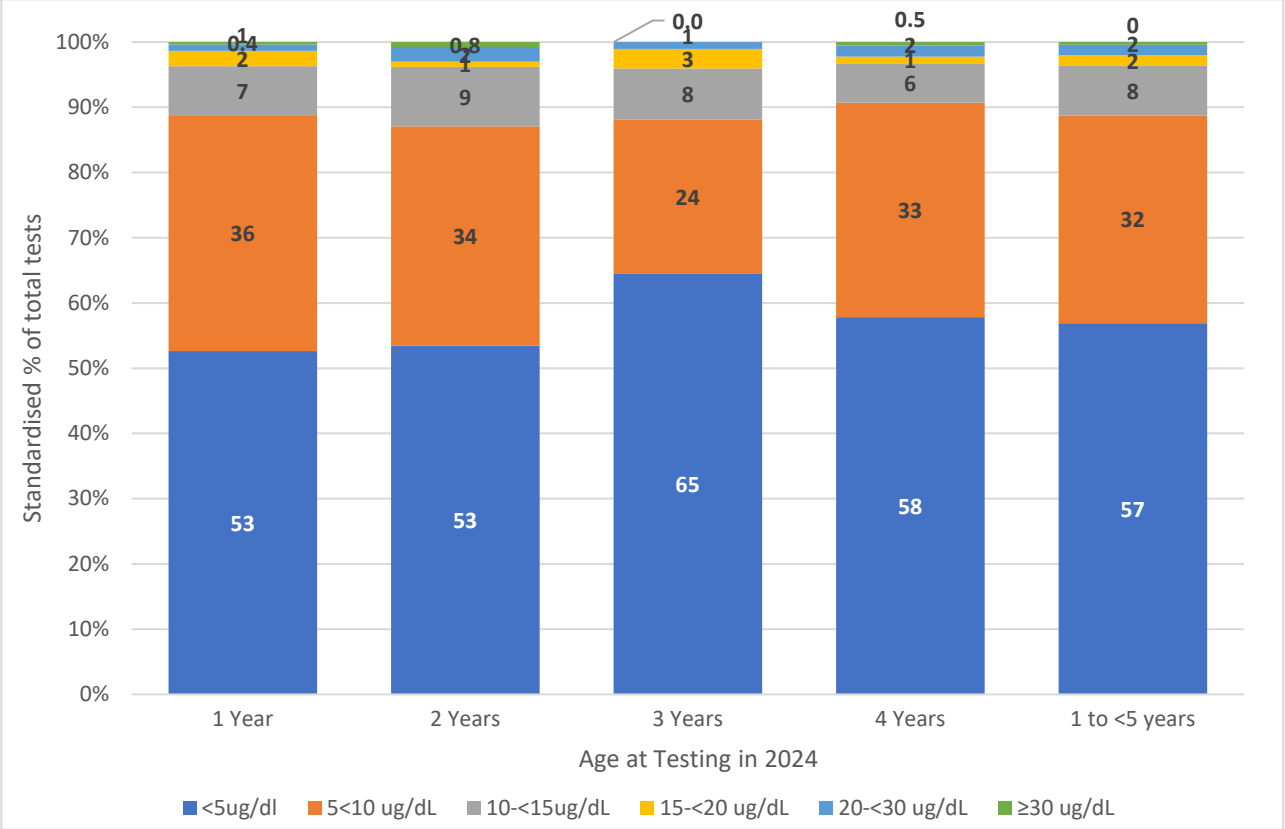

Figure 11: Blood lead levels by category as a percentage of total tests (age-sex standardised percentage) and by 1 year age group for children aged 1 to less than 5 years in Broken Hill, 2024. NB: totals may vary due to rounding.

Looking at the age-sex standardised percentage of children aged 1 year to less than 5 years, screened annually from 2018-2024, it can be seen that 2 years olds have consistently had the highest proportion of children with BLLs of 20 µg/dL and above (Figure 12), with the exception of 2021 where this was marginally higher in 3-year-olds.This too is consistent with annual geometric means being highest in this 2-year-old cohort (Figure 7). Importantly, however, the proportion of 2-year-olds with high BLLs is the lowest it's been since 2021.

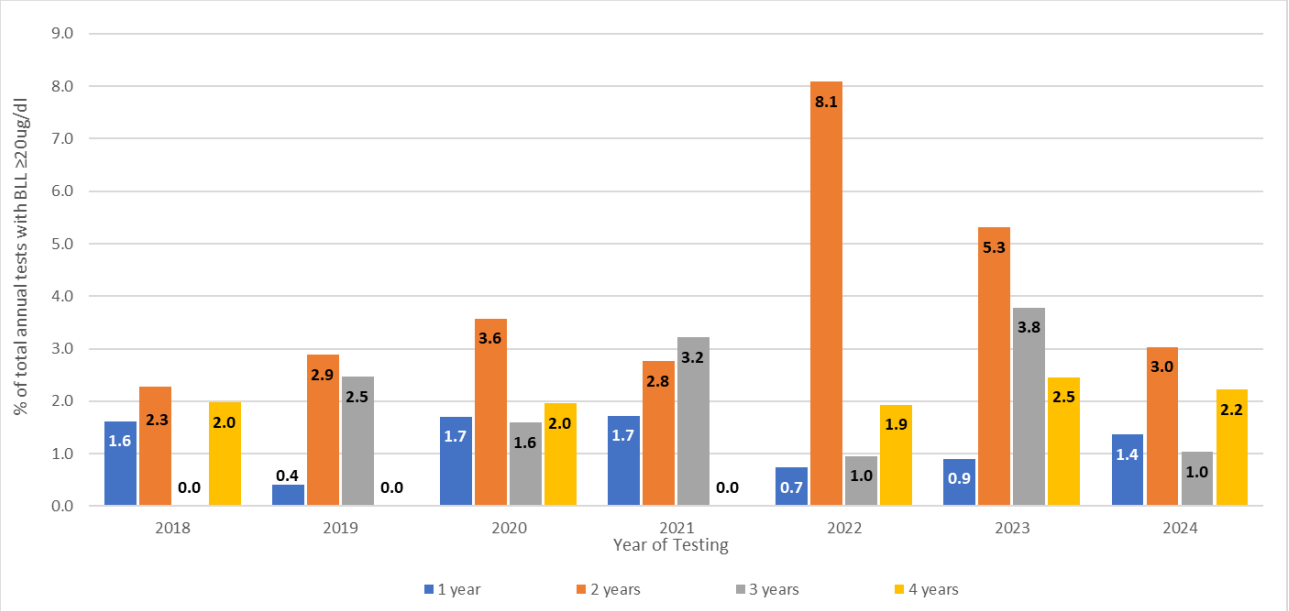

Figure 12: Age-sex standardised percentage of total annual screens with blood lead levels (BLLs) of 20 µg/dL and above and stratified by 1 year age group for children aged 1 to less than 5 years in Broken Hill, 2018-2024. NB: totals may vary due to rounding.

Seasonal trends in blood lead levels of all children aged 1 to < 5 years, 2023

A study by Liu et al, 2021[14] of BLLs in Broken Hill children aged under 5 years from 1991 to 2015 found that higher BLLs were associated with the warmer months (October to March) and lower BLLs in the colder months (April to September). This seasonal association was apparent in 2024, with BLL geometric means for children aged 1 year to less than 5 years highest in the first (January to March) and fourth (October to December) quarters (Figure 13). For the 10-year average of the monthly geometric means, the higher geometric means generally tended to occur during the first quarter of the year followed by the fourth quarter, which includes the warmer months of the year. It should be noted that the seasonal increase in geometric means for the warmer months commenced in September in 2024 which is also evident for the 10-year average. Further, December is the exception to this, as both testing numbers and geometric means are consistently lower in this month.

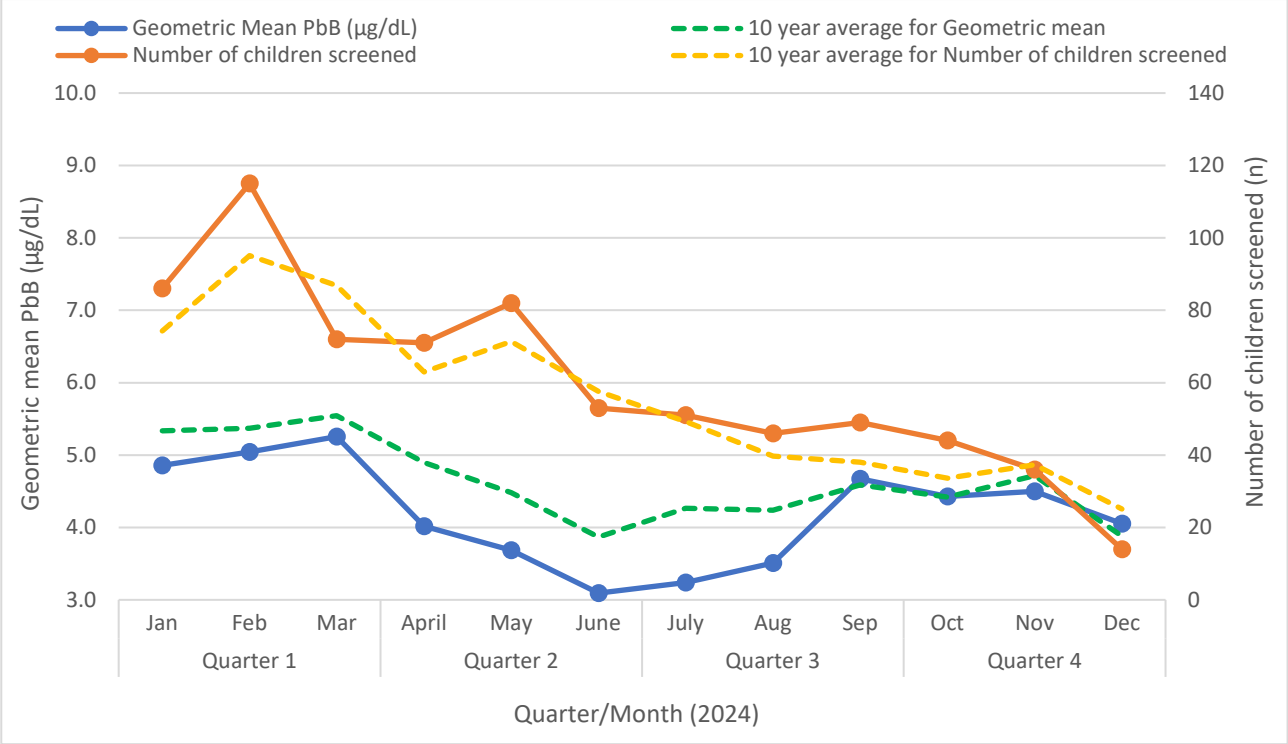

Figure 13: Monthly geometric mean blood lead level comparison of first visit blood lead levels for Broken Hill children aged between 1 to less than 5 years of age, 2024.

In 2024, the quarter with the highest average rainfall was the first quarter (64.8 millimeters) followed by the fourth quarter (20.6 millimeters), which correlate to these same quarters having higher geometric means compared to the second and third quarters. The annual rainfall for 2024 (358.4 millimeters) was 44% higher than the average for 1952-2023 (249.6 millimeters), and 2.3 times that for 2023. Comparing annual geometric means with annual rainfalls for Broken Hill over the past 10 years gave no clear indication of an association between lower BLLs and high rainfall (Figure 14).

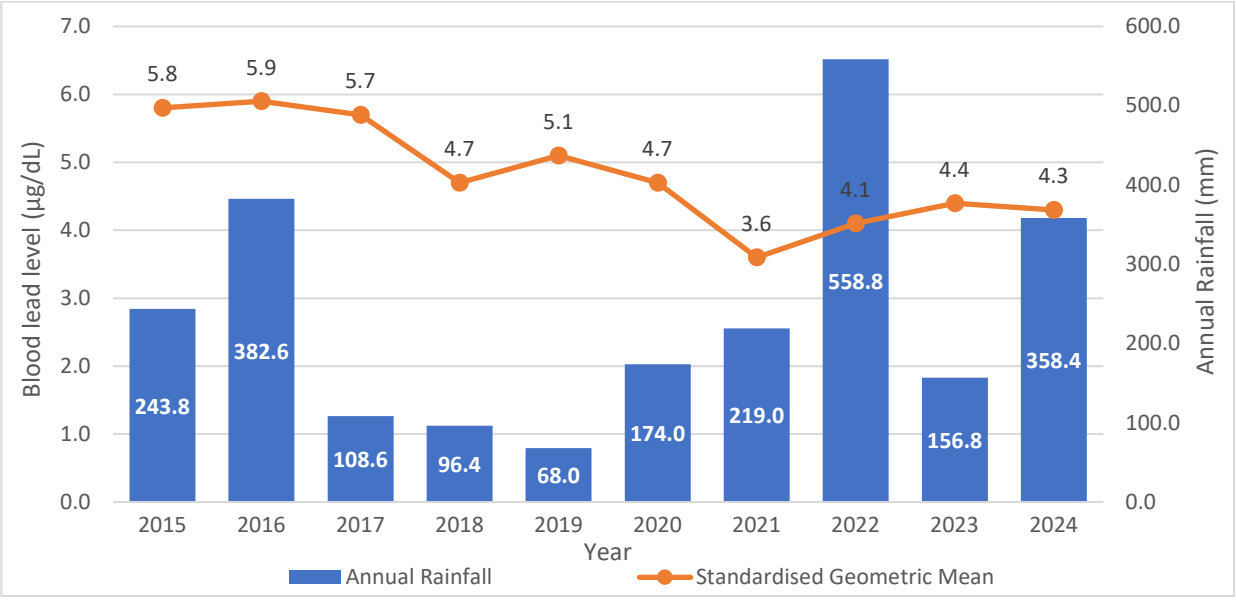

Figure 14: Annual standardised geometric mean of first visit blood lead levels for Broken Hill children aged between 1 to less than 5 years of age, and annual Broken Hill rainfall for 2015-2024.

Also in 2024, the highest numbers of first tests occurred in the first (n=273) and second (n=206) quarters of the year, which is consistent with findings from previous years. However, month by month, there was no obvious association between high testing numbers and higher geometric means (Figure 13).

Conclusion

In 2024, following a detailed internal review, the Maari Ma Health Aboriginal Corporation modified their program delivery model and began implementing first point of care testing lead screening at 12 months of age rather than at 6 months of age. Prior to 2024, the first point of care testing was routinely offered by both services. The Broken Hill Child and Family Health Service continue to screen children from 6 months of age. Consequently, direct comparison with cohort trends from previous years and stratification by Aboriginality status are not appropriate. The high-level analysis for 2024 is presented in Appendix 1.

The number of newborns screened fell minimally in 2024. The proportion of newborns screened from live births at the Broken Hill Health Service has increased since 2016 concurrently with an 18% decrease in live births annually. In contrast, the number of children screened in the 1 to less than 5 years age group increased from 2022 onwards and has been sustained in 2024, with the highest participation rate since 2017. Looking at this by 1 year breakdown, increased participation was seen in all age groups, although screening rates are lowest for the 2- and 3-year-olds, which may be influenced by there being no scheduled National Immunisation Program vaccinations.

Analyses of geometric means across the developmental groups confirm that for newborns the geometric mean continues to be low, with no difference seen between Aboriginal and non-Aboriginal newborns. This measure acts as a proxy baseline for children as they grow and develop, but with their increased interaction with the environment, when rolling, crawling, and grabbing at objects, the geometric mean begins to rise. For the reduced cohort of children aged 6 months to less than 12 months, the geometric mean was increased from that for cord bloods but remaining well within the guideline.

As children transition into the toddler stage (1 year and older), they develop greater autonomy, allowing them more freedom to roam and explore their surroundings. This increases children's exposure to lead and is when their BLLs can rise close to or above the guideline. The 10-year trend for children aged 1 year to less than 5 years has seen the overall geometric mean for this age group fall from above the guideline to being statistically significantly below the guideline consistently since 2021. Nonetheless, the age-sex standardised percentage of children in this cohort with BLLs above the guideline in 2024 was 43% which equates to 337 children.

Importantly, significant disparity remains between Aboriginal children and non-Aboriginal children in the 1 to less than 5 years cohort. From 2018 to 2024, the annual standardised geometric mean for Aboriginal children is approximately twice that of non-Aboriginal children. Similarly, there is a persistent overrepresentation of Aboriginal children in this cohort at high or very high BLLs, with a 10-year average proportion of children with BLLs above the guidelines of 72% for Aboriginal children, in contrast to 35% for non-Aboriginal children in this age group. The number of Aboriginal children aged 1 year to less than 5 years being screened for BLLs decreased slightly in 2024.

Appendix 1: Screening of children aged 6 months to less than 12 months, 2024

Children screened

There were 162 children aged 6 months to less than 12 months screened for BLLs[k].

Blood lead geometric mean and elevated blood lead levels

The annual geometric mean for children screened aged 6 months to less than 12 months was 2.5 µg/dL. Of children screened, 10% (n=16) had BLLs above the guideline, including 12 with BLLs within the range of 5 to less than 10 µg/dL and 4 with BLLs within the range of 10 to less than 15 µg/dL (Figure 15).

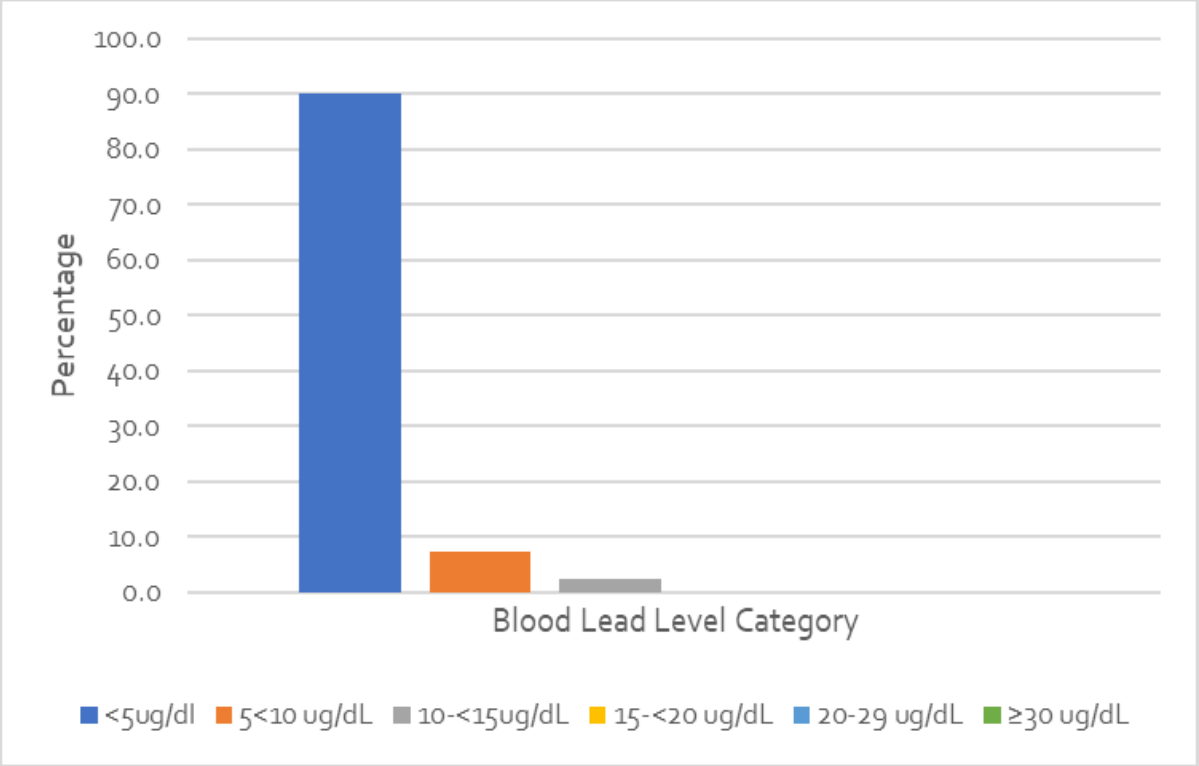

Figure 15: Blood lead levels of children aged 6 to less than 12 months by category as a percentage of total annual tests, 2024.

[k] Participation rates have not been reported for this age group as an ABS Census denominator by six months is not available.

Appendix 2: Unadjusted geometric means, with 95% CI

Table 4: Broken Hill children aged 1 year to less than 5 years. Unadjusted annual geometric means with 95% confidence intervals and age-sex standardized geometric means (std GM), 2015-2024.

Year	Children tested	Unadjusted geometric mean	95 CI+	95 CI -	age-sex std GM
2015	679	5.7	6.16	5.44	5.8
2016	687	5.8	6.31	5.49	5.9
2017	730	5.5	6.09	5.31	5.7
2018	637	4.6	5.08	4.32	4.7
2019	681	5.1	5.45	4.75	5.1
2020	689	4.7	5.04	4.36	4.7
2021	561	3.5	3.82	3.16	3.6
2022	619	3.9	4.39	3.44	4.1
2023	711	4.2	4.66	3.78	4.4
2024	**718**	**4.2**	**4.57**	**3.93**	**4.3**

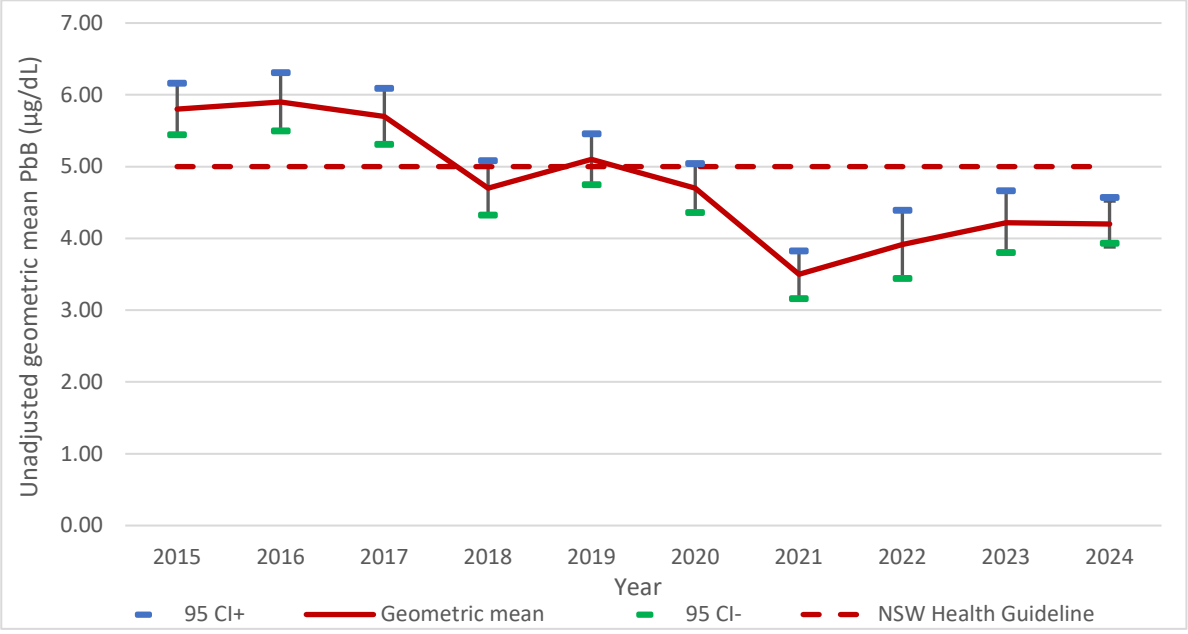

Figure 16: Children aged 1- less than 5 years, unadjusted annual geometric means with 95% confidence intervals, 2015-2024, and NSW Health guideline (<5µg/dL).

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