Hazelwood Health Study Technical Report:
2022 Survey of Early Life Follow-Up (ELF) Parents and Families

An investigation of how parental mental health and family wellbeing have shaped child mental health and wellbeing after the 2014 Hazelwood mine fire

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Caveat

This research was funded by the Victorian Department of Health. However, the report presents the views of the authors and does not represent the views of the Department.

This report presents a preliminary analysis which has not been submitted to independent peer review. Subsequent scientific manuscripts which undergo independent peer review may vary in their findings or interpretation.

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Abbreviations

ADHD	Attention-Deficit / Hyperactivity Disorder
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
CATI	Computer-assisted telephone interview
CAWI	Computer-assisted web interview
CSIRO	Commonwealth Scientific and Industrial Research Organisation
C-index	Harrell's Concordance Index
DoB	Date of birth
ELF	Latrobe Early Life Follow-Up Study
HHS	Hazelwood Health Study
IQR	Inter-quartile range
K10	Kessler 10-item psychological distress scale
LGA	Local government area
M	Mean
MUHREC	Monash University Human Research Ethics Committee
OR	Odds ratio
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 micrometres (thousandths of a millimetre) or less
PSS	Parental Stress Scale
PTSD	Posttraumatic Stress Disorder
REDCap	Research Electronic Data Capture software application
r_s	Spearman's rank correlation coefficient
R^2	Coefficient of determination
SD	Standard deviation
SDQ	Strengths and Difficulties Questionnaire
SEHQ	School Entrant Health Questionnaire
SF-12	12-Item Short Form Survey
UTas	University of Tasmania
UTas REU	University of Tasmania Research Ethics Unit
95% CI	95% Confidence interval
$\mu g/m^3$	Micrograms (millionths of a gram) per cubic meter of ambient air

1. Executive Summary

The 2014 Hazelwood mine fire had potential to impose acute pressures and concerns on parents and families of infants and young children, including those parents and families who were expecting the birth of a new baby. The Latrobe Early Life Follow-up (ELF) cohort) was established via a parent-completed survey in 2016 (the ELF baseline survey) to compare health outcomes between three exposure groups: children exposed in early life (first two years); children exposed *in utero*; and children born in the year after the fire so were not exposed. The *2022 HHS Survey of Early Life Follow-Up (ELF) Parents and Families* (the 2022 survey) was undertaken with the objective of exploring the longer-term relationship between exposure to smoke, and parent and child mental health, among families in the ELF study cohort. The current study investigated three research questions:

Research question one: What is the longer-term state of mental health in children and parents who were resident in Latrobe City at the time of the Hazelwood mine fire?

Research question two: What is the relationship between exposure in early life to smoke during the 2014 Hazelwood mine fire and child mental health eight years later, and how is this influenced by parent, child and family-wide factors?

Research question three: What is the relationship between exposure to smoke during the 2014 Hazelwood mine fire and parent mental health eight years later, and how is this influenced by parent, child and family-wide factors?

A quantitative research methodology was implemented that utilised psychometrically validated measures of child and parent mental health and wellbeing in conjunction with baseline sociodemographic and health information collected in previous ELF research activities. The primary child mental health and wellbeing outcomes assessed in the study were the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) and parent-reported mental health diagnoses, and the primary parent mental health and wellbeing outcomes assessed were the Kessler General Psychological Distress Scale (K10; Kessler & Mroczek, 2004) and the Parental Stress Scale (PSS; Berry & Jones, 1995). Sections of the Student Entrant Health Questionnaire (SEHQ; Avant et al., 2005) were used to assess the prevalence of family issues impacting the families of participants. Measures to investigate and account for potential impacts of the COVID-19 pandemic and 2019-2020 Black Summer bushfires, on both child and parent mental health and wellbeing outcomes, were incorporated into the study design.

Data collection in the 2022 survey was conducted between May and August 2022, five and a half years after participants completed the original 2016 ELF Baseline Survey, and eight years after the 2014 Hazelwood mine fire event (February-March 2014). In total, 227 parents of 249 children participated in the 2022 survey.

Results indicated that there were no significant differences in either child or parent mental health outcomes between the three exposure groups. While there were no differences between exposure groups, all groups scored higher than would be expected on many of the mental health and wellbeing outcomes. Across the study cohort as a whole, there were indications of high rates of childhood mental health diagnoses, emotional and behavioural difficulties, family problems, and general psychological distress among parents. Overall, 27% of children whose parent participated in the 2022 survey had a mental health diagnosis, more than double a recent international estimate of 12.7% drawn from findings from 11 high-income countries including Australia (Barican et al., 2022). The predominant mental health conditions in children were Anxiety (16%), Attention-deficit/hyperactivity disorder (ADHD) (13%), and Autism spectrum disorder (ASD) (10%). The overall mean SDQ total difficulties score (10.60) placed the child cohort in the "close to average" band; however, 24% of children in the cohort scored in the "high-risk" band.

Comparison of SDQ and family issues results between the 2022 survey sample and 2021 SEHQ results for Latrobe City and Victoria (Victorian Department of Education & Training, 2021) suggested that children included in the 2022 survey were more frequently affected by emotional and behavioural problems than would be expected based on local government area (LGA) and state-level data. Likewise, a higher proportion of families in the 2022 ELF Survey had more problems in their family histories and were experiencing greater levels of family stress than families in Latrobe City or wider Victoria. These results indicated that, relative to the region or the state, a disproportionate number of primary school-aged children were living in adverse circumstances affecting their mental health.

The 39% of families participating in the study who had a parent with a mental health diagnosis in their history was consistent with Australian Bureau of Statistics (ABS) national estimates of 40% (ABS, 2023a). In around half of these cases, the diagnosis had a current impact on the parent's functioning. The mean K10 score for participating parents (21.2) places them at the cusp of the "high psychological distress" band as defined by ABS scoring guidelines, with 41% of parents scoring either high or very high on the measure. This is substantially higher than estimates for the Latrobe City LGA (ABS, 2023b) and for wider Gippsland (ABS, 2023b), suggesting respondents to this survey were more psychologically distressed than the general community. The mean PSS score for participating parents (35.8) placed them within a normal expected range, however, parents of children with a diagnosed medical condition, or children recently affected by a family challenge such as a relationship breakdown or job loss, were particularly susceptible to higher levels of parental stress. Importantly, having a greater level of concern in relation to the COVID-19 pandemic was associated with higher levels of both general psychological distress and parental stress. Importantly, comparisons with 2021 ABS census data for Latrobe City suggest that the 2022 survey cohort were more likely to have had two parents or carers in the household, and that the cohort had higher levels of education, employment, and income in the household (ABS, 2022).

In summary, the sample-wide high rates of childhood mental health diagnoses, emotional, and behavioural difficulties found in the present study do not appear directly attributable to impacts of exposure to smoke emitted by the 2014 Hazelwood mine fire, whether in early childhood or during gestation. However, the differences between this survey sample and that of the wider Latrobe region and populations more broadly, suggest that families facing particular challenges may have been more likely to take up the invitation to respond to a survey on longer-term child and family health and wellbeing outcomes following the mine fire. This greater likelihood for parents experiencing family challenges to participate in a post-mine fire study suggests there may be ongoing concerns in relation to the mine fire in these families. Regardless, the findings presented here strongly indicate that the mental health and wellbeing of children, parents, and families in the Latrobe City should be a focus of further investigation and specific intervention.

2. Introduction

2.1 Child and parent mental health and wellbeing in the context of disaster

The mental health of children and their parents is intimately connected. From the time of pregnancy onwards, parents relay information about the world to their children through biological processes (Bateson et al., 2014), behaviour (Gerull & Rapee, 2002), and communication (Tabak et al., 2012). Hence, parental mental health and wellbeing is a primary determinant of childhood mental health and wellbeing (Achtergarde et al., 2015). Association between the mental health of parents and their children is a combination of genetic inheritance, relational dynamics, family climate, and shared life circumstances and experiences (Polderman et al., 2015; Reupert et al., 2012). The mental health of parents and their children is interdependent, meaning that the mental health and wellbeing of children can also influence the mental health and wellbeing of their parents, typically through the responsibilities, challenges, and burdens that parental roles can involve (Fudge et al., 2004). The ways in which parents appraise and respond to the experiences and needs of their children, particularly when potentially traumatising events are encountered, are integral to whether childhood mental health problems will emerge and, in cases where a problem does emerge, the prospects for recovery (Hillier et al., 2018).

With the advent of climate change, the frequency and severity of major disasters caused by extreme weather events have increased globally (Ripple et al., 2024). Children are among the most vulnerable to adverse outcomes after disaster (Danese et al., 2020). Detrimental impacts of disaster on children's mental health and wellbeing can occur through physical injuries or exposure to contaminants, psychologically traumatising aspects of their disaster experience, disruptions caused to essential services in the disaster-affected community, and interruptions caused to the regular patterns and routines of the children's day-to-day lives (Masten & Osofsky, 2010). Children's mental health and wellbeing outcomes are also shaped by what impacts a disaster has on parents, their parenting, and the family as a whole (Masten & Narayan, 2012; Morris et al., 2012; Conway et al., 2013). Association between impacts of disaster on parental and family functioning and post-disaster child mental health outcomes is evident across age-ranges spanning infancy to late adolescence (Cobham et al., 2016), which extends to cases where children were *in utero* at the time of the event or were conceived shortly afterwards (Lafortune et al., 2021).

Parenting can be physically and emotionally challenging even in the best of times (Milligan, 2005). The influx of stressors during and after disasters makes parenting an even more complex and difficult undertaking (Bonanno et al., 2010). Compounding the extra demands and pressures involved in ensuring children's physical safety and emotional wellbeing during disaster, parents are likewise in the midst of navigating immediate and longer-term impacts of the event that may be directly destabilising to their own health and wellbeing (de Vet et al., 2021). In these circumstances parents frequently feel overwhelmed (Coffman, 1996), parenting styles are susceptible to becoming overprotective (Cobham & McDermott, 2014), and the capacities of some parents to recognise and appropriately respond to their child's needs can be impeded (Hafstad et al., 2012). Studies conducted in post-disaster contexts have observed associations between parental psychopathology and child behavioural and emotional problems (North et al., 2018), between parents' and their children's posttraumatic stress disorder symptoms (Jones et al., 2002), and between suboptimal family functioning and childhood anxiety (Kiliç et al., 2003). However, Cobham and colleagues' (2016) recent systematic review emphasised the need for further investigations that contribute to better understanding the role of parenting and the family environment in shaping children's mental health and wellbeing after disaster.

2.2 The 2014 Hazelwood mine fire

During February and March 2014, bushfire embers ignited a fire in the Morwell open-cut brown coal mine adjacent to the Hazelwood Power Station, causing a mine fire period of excessive smoke which impacted on the town of Morwell and other localities in the Latrobe City local government area (LGA) in Victoria, Australia (Luhar et al., 2020). The smoke event continued for approximately six weeks and was unusual in terms of the intensity, duration, and proximity to population centres. In response to community concerns about the health impacts of exposure to the smoke, the

Victorian Government Department of Health commissioned the Hazelwood Health Study (HHS), which is a program of research with several research streams, each with their own specific aims and objectives. Several findings in relation to mental health and wellbeing have stemmed from the HHS's body of work. Longitudinal research undertaken with adults in the community indicated that the level of smoke exposure during the mine fire was associated with level of event-related posttraumatic stress (Broder et al., 2020; Carroll, Campbell et al., 2022; Carroll et al., 2024; Maybery et al., 2020); event-related posttraumatic stress outcomes across the community were also determined by sociodemographic circumstances and other adverse life-events (Smith et al., 2023). Analyses of local health service datasets implicated the mine fire in swells in demand for mental health care (Carroll, Gao et al., 2022) and prescriptions of psychiatric medications (Johnson et al., 2019). Longitudinal research undertaken in local primary and secondary schools found that the mine fire was associated with posttraumatic stress among school-aged children (Maybery et al., 2024) and had caused disruptions to academic progress within local schools (Berger et al., 2023; Gao et al., 2023). While the HHS has produced extensive evidence on the mental health impacts of the mine fire on adults and children, there is a need to explore the role of the family environment on child and parent outcomes. This report represents a cross-stream activity bringing together the HHS' Psychological Impacts and Latrobe Early Life Follow-up (ELF) Study streams to investigate the longer-term mental health and wellbeing of children in earlier stages of life, their parents, and their families in the aftermath of the mine fire.

2.3 Study aims, objectives, and research questions

The 2014 Hazelwood mine fire had potential to impose acute pressures and concerns on parents and families of infants and young children, including those parents and families who were expecting the birth of a new baby. Accordingly, the *2022 HHS Survey of Early Life Follow-Up (ELF) Parents and Families* was undertaken with the objective of exploring the relationship between exposure and parent and child mental health among families in the ELF Study cohort. The current study investigated three research questions:

Research question one: What is the longer-term state of mental health in children and parents who were resident in Latrobe City at the time of the Hazelwood mine fire?

Research question two: What is the relationship between exposure in early life to smoke during the 2014 Hazelwood mine fire and child mental health eight years later, and how is this influenced by parent, child and family-wide factors?

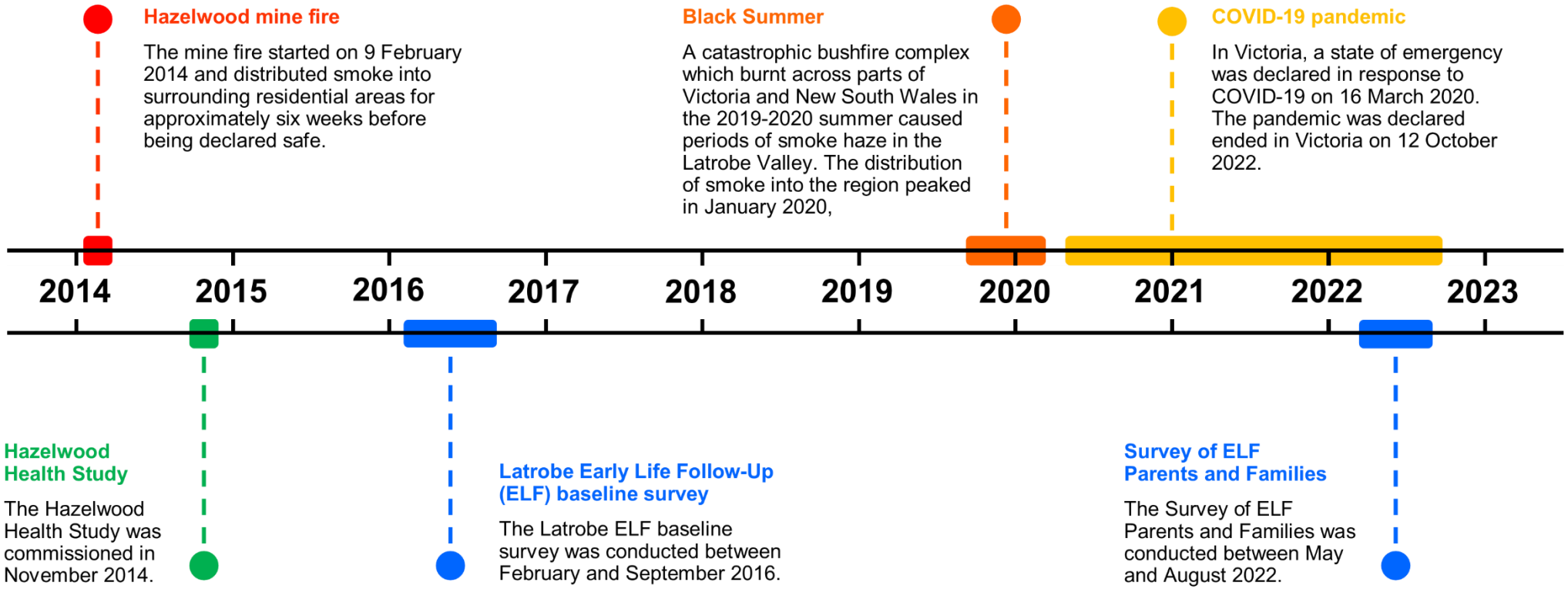
Research question three: What is the relationship between exposure to smoke during the 2014 Hazelwood mine fire and parent mental health eight years later, and how is this influenced by parent, child and family-wide factors?

3. Method

3.1 Study design

The 2022 Survey of ELF Parents and Families was an assessment of child, parent, and family mental health and wellbeing within the continuing longitudinal ELF research cohort (see Melody et al., 2020). A quantitative research methodology was implemented that utilised psychometrically validated measures of parent mental health and wellbeing, child mental health and wellbeing, and family functioning in conjunction with baseline sociodemographic and health information collected in previous ELF research activities. Measures to investigate and account for potential impacts of the COVID-19 pandemic and 2019-2020 Australian Black Summer bushfires on both child and parent mental health and wellbeing outcomes were incorporated into the study design. Data collection in the 2022 survey was conducted between May and August 2022. The 2022 survey took place some five and a half years after participants completed the original 2016 ELF Survey, and some eight years after the 2014 Hazelwood mine fire event (February-March 2014). Figure 1 presents a timeline of the research within the context of significant events that have occurred in the community over that period.

Figure 1 Timeline of the Research Within the Context of Significant Events in the Community



3.1.1 Participant eligibility

The ELF Study cohort was established in 2016 and comprises children born between 1st March 2012 and 31st December 2015 in Latrobe City, Victoria, Australia, as well as their parents or caregivers. (Melody et al., 2020). The geographic catchment for the cohort included the entire Latrobe City municipality, which encompasses the major towns of Morwell, Moe, Traralgon, Newborough, Churchill, and Yallourn. Records maintained by the Latrobe City Council Maternal Child Health Service indicated the eligible population for the cohort was 3,371. The original ELF cohort comprised 573 children from 528 families whose parent or caregiver participated in a baseline survey that investigated demographic, health, smoke exposure, and housing characteristics (Melody et al., 2020). As part of the ELF baseline survey, participants were informed of the possibility of periodic invitations to participate in further surveys and interviews as part of the HHS's longitudinal program of research. Participants were invited to voluntarily provide contact details that might be used to contact them in relation to participating in these future research activities.

Participating children were recruited into either of three exposure groups based on their dates of birth (DoB), which were used to determine whether they had been exposed in early life or whilst in utero[1], or were conceived after the mine fire and hence not exposed (which served as the control group). The details of these three groups were as follows:

Early life exposure to mine fire smoke. Parents of children aged 0-2 years at the start of the mine fire (eligible child DoBs: *1 March 2012 – 9 February 2014*). These children were aged 8-10 years at the time of the 2022 survey.

***In utero* exposure to mine fire smoke.** Parents of children in gestation during the time of the mine fire (eligible child DoBs: *10 February 2014 – 31 December 2014*). These children were aged 7-8 years at the time of the 2022 survey.

Unexposed to mine fire smoke (control group). Parents of children conceived approximately 1-12 months after the time of the mine fire (eligible child DoBs: *1 January 2015 – 31 December 2015*). These children were aged 6-7 years at the time of the 2022 survey.

While the ELF study has identified the above three primary exposure groups, a small number of children were born during the mine fire period, and so had some exposure in early life as well as in utero. A review of the exposure levels of these mixed exposure children indicated that they were very similar to those exposed in utero, and so they were merged with the in utero exposure group for the purposes of this analysis.

All families that participated in this baseline survey, with the exception of those that had subsequently actively withdrawn from the ELF cohort or had been identified as lost to further contact in previous ELF research, were eligible for invitation to participate in the 2022 survey. In total, 427 families of 465 children were invited to participate.

3.1.2 Contact and recruitment

The initial approach to families, notifying them of the 2022 survey, was managed by the HHS ELF research stream, which held the contact details for the cohort. The parent or carer listed as the primary family contact in ELF records was mailed a written invitation and information sheet about the survey. Families that did not wish to participate in the survey were invited to opt out from receiving further approaches regarding the 2022 survey.

After two weeks, the primary contact details for all families that had not opted out were made available to the HHS Psychological Impacts research stream to manage invitations to participate in the 2022 survey. Invitations to participate in the survey were distributed to families in a variety of ways. The type of contact attempted was dependent on the completeness of their contact details listed in the ELF participant database. Contact attempts prioritised email, followed by SMS, phone call, and finally postal letter. Two attempts were made for each approach modality. Contact attempts were scheduled at one-week intervals and continued until a survey response was received or until all scheduled contact attempts for each available modality were exhausted. Email and SMS invitations included a web link providing prospective participants direct access to the explanatory statement and online survey, instructions detailing how to

[1] By convention, "in utero" should be italicised. However, in this report "in utero" served as a label for one of three exposure groups, so we opted not to italicise the term throughout the report.

arrange a telephone or mail survey completion, and instructions detailing how to opt out of the study. Postal invitations provided similar information, with the addition of a printed version of the explanatory statement.

3.1.3 Survey formats

To facilitate accessibility and maximise participation, participants were offered three ways to complete the 2022 survey:

Computer-assisted web interview (CAWI): Online version of the survey to be completed by the participant.

Computer-assisted telephone interview (CATI): A survey conducted over the telephone, facilitated by a research team member, at a time nominated to be convenient by the participant.

Postal response: Paper copy sent via postal mail by the research team and mailed back by the participant.

Participants were able to access and complete the online survey at a time and pace convenient to them. Participants were also able to indicate if they preferred not to answer any survey item. As reimbursement for their time, at completion of the 2022 survey, participants were eligible to receive a $25 e-gift voucher for each child they had enrolled in the ELF cohort. No requests were received to do the paper version of the survey, and only a very small number of surveys were completed over the phone, with almost all participants completing the survey online.

3.1.4 Survey instrument

The survey was designed to be completed by only one parent or carer, who provided information on themselves, any other parents or carers, the ELF child/ren and the wider family. While the invitations were sent to the primary contacts for each ELF family, the 2022 survey allowed for the possibility that another parent or carer could complete the survey, including collecting additional detail on the new respondent.

The 2022 survey comprised measures of sociodemographic factors, parent mental health and wellbeing, child mental health and wellbeing, and family functioning. The survey also included items investigating the impacts of the 2019-2020 Black Summer bushfires event that directly impacted nearby regions and distributed heavy smoke across Latrobe City, and the impacts of the COVID-19 pandemic, which had potential to influence outcomes of interest in the study.

Some families had more than one child in the ELF cohort (number of enrolled children in families ranged 1-4) and participants were asked questions relating to other parents or caregivers in the household (number of other parents or caregivers in the household ranged 0-6). Accordingly, the 2022 survey was structured to repeat child-focused questions for each child the participating parent or caregiver had enrolled. Likewise, questions which focused on other parents or caregivers in the household were repeated for each parent or caregiver identified by the first participant.

Section A: Contact details

A set of items recording participant address, email, and telephone contact details.

Section B: Family composition

A set of items exploring the numbers of other (non-ELF cohort) children and adults living in the family home, including the sex and relationship to the child of any other parents or caregivers living in the family home.

Section C: Household sociodemographic information

A set of items investigating education level and employment status of each parent or caregiver in the household, as well as household income.

Section D: Impacts of recent events in the community

COVID-19 pandemic concerns. A set of items developed specifically for the 2022 survey to investigate diagnoses of COVID-19 within the household and levels of concern regarding physical, mental health, social, and economic impacts of the COVID-19 pandemic. Six items described a potential impact related to the pandemic (e.g., “How lonely are you as a result of the COVID-19 pandemic?”) and respondents indicated to what degree each had concerned them on a 7-point scale (1: “Not at all”; 2-6: [not defined]; 7: “Extremely”). Participants’ scores for each item were summed to generate a COVID-19 pandemic concerns score (scoring range: 6-42), with higher scoring indicative of a greater level of concern in relation to the event.

2019-2020 Black Summer concerns. A set of items developed specifically for the 2022 survey to investigate physical and mental health impacts of the Black Summer bushfire event that impacted southeastern Australia during 2019-2020. Five items described potential impacts related to the bushfires (e.g., "Are you or your family currently experiencing any physical health concern as a result of the 2019-2020 bushfire and smoke event?") and respondents indicated to what degree each had concerned them on a 7-point scale (1; "Not at all"; 2-6: [not defined]; 7 = "Extremely"). Participants' scores for each item were summed to generate a Black Summer concerns score (scoring range: 5-35), with higher scoring indicative of a greater level of concern in relation to the event.

Section E: Parent and caregiver mental health and wellbeing

Kessler Psychological Distress Scale (K10; Kessler & Mroczek, 2004). The K10 is a screening scale for assessing symptoms of general psychological distress experienced in the previous four weeks. Each item describes a typical symptom of anxiety or depression (e.g., "About how often did you feel nervous?") and respondents indicate the degree to which they have experienced each over the previous four weeks on a 5-point scale (1: "None of the time"; 2: "A little of the time"; 3: "Some of the time"; 4: "Most of the time"; 5: "All of the time"). The K10 is unidimensional and a total score is all items summed. The K10 scoring range is 10-50, with higher scoring indicative of greater psychological distress. K10 scores were categorised into four levels of severity (scores ≤15: "Low psychological distress"; scores 16-21: "Moderate psychological distress"; scores 22-29: "High psychological distress"; scores ≥30: "Very high psychological distress") based on the approach routinely implemented in ABS surveys (ABS, 2012).

Self-reported general health status (SF-12; Roelen et al., 2014). The single-item assessment of general health from the 12-Item Short Form Survey was administered as a brief measure of current health status. Respondents rate their level of general health on a 5-point scale (1: "Poor"; 2: "Fair"; 3: "Good"; 4: "Very good"; 5: "Excellent").

Mental health history of the participating parent or caregiver. A set of self-report items investigating whether the participant has had a diagnosed mental health condition and, if so, the year the condition was first diagnosed and to what degree the condition currently affects their daily functioning ("Does not affect the parent or caregivers' daily functioning"; "Mildly affects the parent or caregivers' daily functioning"; "Moderately affects the parent or caregivers' daily functioning"; "Severely affects the parent or caregivers' daily functioning").

Mental health history of other parents and caregivers in the household. A set of items, completed by the participant in relation to each of the other parents or caregivers in the household, investigating whether the parent or caregiver has had a diagnosed mental health condition and, if so, the year the condition was first diagnosed and to what degree the condition currently affects their daily functioning ("Does not affect the parent or caregivers' daily functioning"; "Mildly affects the parent or caregivers' daily functioning"; "Moderately affects the parent or caregivers' daily functioning"; "Severely affects the parent or caregivers' daily functioning").

Section F: Family functioning and wellbeing

SEHQ Family Issues section (Avant et al., 2005). The 2022 survey included components of the School Entrant Health Questionnaire (SEHQ) routinely administered by the Victorian Department of Education and Training to families of children commencing Grade Prep. The SEHQ Family Issues section comprises three components exploring exposure to problems or events associated with vulnerability to health, development, and behavioural problems in childhood. The first component presents ten challenging family situations (e.g., "Parent / caregiver's loss of job") and respondents indicate the degree to which their child has been affected by each over the previous 12 months on a 3-point scale (0: "Not true"; 1: "Somewhat true"; 2: "Certainly true"). For the present study, the "Somewhat true" and "Certainly true" response options were combined to create a dichotomous variable (0: "Not true"; 1: "True"). The second component presents seven potentially problematic family situations (e.g., "Gambling problem in the family") and respondents indicate whether each has occurred within the family's history (0: "No"; 1: "Yes"). The final component is a single item where respondents rate their family's current stress level on a 5-point scale (1: "Little or no stress / pressure"; 2: [not defined]; 3: "(middle)"; 4: [not defined]; 5: "Almost more than I can bear"), with higher scores indicative of a greater family stress.

Parental Stress Scale (PSS; Berry & Jones, 1995). The PSS is an 18-item assessment of parents' feelings about their parenting role. The PSS explores both positive aspects of the parenting experience, such as emotional benefits and personal development, and negative aspects of the parenting experience, such as demands on resources and feelings of stress. Each PSS item describes a feeling or perception about the parenting experience (e.g., "I sometimes worry whether I am doing enough for my child") and respondents indicate the degree to which each statement applies to them on a 5-point scale (1: "Strongly disagree"; 2: "Disagree"; 3: "Undecided"; 4: "Agree"; 5: "Strongly agree"). The PSS scoring range is 18-90, with higher scoring indicative of greater parental stress.

Section G: Child mental health and wellbeing

Child mental health history (parent-report of formal diagnoses). A set of items relating to seven of the most frequent childhood mental health diagnoses: "Anxiety"; "Depression"; "Posttraumatic stress disorder (PTSD)"; "Attention-deficit / Hyperactivity Disorder (ADHD)"; "Conduct Disorder"; "Oppositional Defiant Disorder"; "Autism Spectrum Disorder (ASD)", as well as "Other mental health conditions", including year of diagnosis.

Strengths and Difficulties Questionnaire: Parent Report (SDQ; Goodman, 1997). The SDQ is a behavioural screening questionnaire for children and adolescents aged 4-17. The SDQ is available in multiple age-specific versions that can be administered to parents, educators, or older children. The SDQ version for Australian parents or educators of children aged 4-10 years was utilised in the 2022 survey, which is the same version of the SDQ routinely included in the SEHQ administered by the Victorian Department of Education and Training to families of children commencing primary school. The SDQ comprises 25 items organised into five subscales (five items per subscale), being four "Difficulties" domains ("Emotional Problems"; "Conduct Problems"; "Hyperactivity"; "Peer Problems") and a single "Strengths" domain ("Prosocial Behaviour"). Each item describes an example of physical, social, and emotional behaviours observed in childhood (e.g., "Generally well behaved, usually does what adults request") and respondents indicate the degree to which each behaviour applies to their child on a 3-point scale (0: "Not true"; 1: "Somewhat true"; 2: "Certainly true"). An SDQ total difficulties score is the sum of the four difficulties domain scores and ranges 0-40, with higher scoring indicative of more behavioural difficulties. SDQ total difficulties scores can be classified into four bands of severity (scores 0-13: "Close to average"; scores 14-16: "Slightly raised"; scores 17-19: "High"; scores 20-40: "Very high"). Based on this classification system, an SDQ total score ≥17 was used as a threshold to define high-risk in the study; at the SDQ domain level high-risk was defined as follows: Emotional problems scores ≥5; Conduct problems scores ≥4; Hyperactivity scores ≥8; Peer problems scores ≥4; Prosocial behaviour scores ≤6.

3.1.5 Data used from previous ELF research

The study utilised data previously collected in ELF research, with data from the 2016 ELF baseline survey linked to the 2022 survey (Melody et al., 2020) using the child's unique ELF ID for the current analysis.

Smoke exposure data

Exposure to $PM_{2.5}$ directly attributable to the mine fire was previously estimated for each participating child (see Melody et al., 2020). The estimation involved superimposing the Commonwealth Scientific and Industrial Organisation's (CSIRO) spatiotemporal chemical transport modelling of $PM_{2.5}$ distribution spanning 51 days from the beginning of the mine fire (9 February 2014 to 31 March 2014) onto time-activity diaries detailing the daily whereabouts of the child or pregnant mother for the same time-period, which were completed by a parent or caregiver as part of the baseline ELF survey. From this data, a daily mean and peak exposure to $PM_{2.5}$ attributable to the mine fire was determined for each child. In the 2022 survey data, the daily mean mine fire-related $PM_{2.5}$ exposure was 8.7 $\mu g/m^3$ (*SD* = 10.3 $\mu g/m^3$) for children in the early life exposure group and was 9.1 $\mu g/m^3$ (*SD* = 10.5 $\mu g/m^3$) for children in the in utero exposure group; children in the unexposed group were assigned control values of 0 $\mu g/m^3$ for all mine fire-related $PM_{2.5}$ exposure metrics.

Baseline demographic and health data for children participating in the ELF study

Data collected at the baseline survey in relation to age, sex, First Nations status, and country of birth of the child, as well as any medical diagnoses the child had (asthma; lung conditions; heart conditions; ear, nose and throat conditions; other conditions considered of concern following a review by the study authors), were utilised in the study.

Baseline demographic and health data for parents of children participating in the ELF study

Data collected at the baseline survey in relation to age, sex, current residence, country of birth, education level, and employment status of the responding parent or caregiver, as well as their relationship to the participating child, were utilised in the study. Additional baseline data in relation to smoking status, number of caregivers in the household, mother's overall stress level when pregnant, whether the child's mother was living in Morwell (which was the most severely affected region of Latrobe City during the mine fire), and mine fire-related stress ratings for both mothers and fathers were used in the comparison of characteristics of responders and non-responders to the 2022 survey.

3.1.6 Data used from other sources

In the state of Victoria, the SEQH is administered in schools each year to parents of children enrolled into grade prep and annual summaries of results by LGA is published. Publicly available Latrobe City and Victorian SEHQ results for 2021 (Victorian Department of Education and Training, 2021) were obtained to compare with the 2022 survey results.

3.2 Data management

The web-based application Research Electronic Data Capture (REDCap; Harris et al., 2009; 2019), hosted by Monash University, was used to distribute 2022 survey invitations and manage data collection processes. All data were subject to statistical checks for missing, invalid, inconsistent, and outlying results. Decision rules governing data cleaning were applied where such problems were detected. At the end of the opt-out period outlined above, information about the primary carer (including name and contact details) and participating ELF children (first name and study ID number) was imported into REDCap to commence recruitment into the 2022 survey. Upon completion of data collection, participant's data were linked to their previous ELF baseline survey data and $PM_{2.5}$ exposure metrics.

3.3 Statistical analyses

Statistical analyses were performed using Stata version 17 (StataCorp, 2021).

3.3.1 Assessments of response bias and representativeness

Baseline survey data for responders and non-responders to the 2022 survey, were compared to assess for selection biases (see Table A1). Categorical data were compared using Fisher's exact test and continuous data were compared using a two-sample *t*-test. Differences between responders and non-responders were used to inform potential confounder selection in the regression modelling and address potential participant selection biases.

Additionally, SEHQ results relating to assessment of family issues and the SDQ for the 2022 survey sample were compared with results in the 2021 Latrobe City LGA report (Victorian Department of Education & Training, 2021). Due to differences in the age profiles in the respective datasets (the Latrobe City LGA report related to children around 5 years of age whereas the age-range of those in the 2022 survey cohort was 6-10 years), a simple descriptive comparison without accompanying statistical hypothesis testing was conducted to obtain a general indication of the representativeness of the study sample relative to the local region.

3.3.2 Data completeness and imputation for missing values

Missing data for sociodemographic and health variables typically ranged 0-1%, with notable exceptions being estimated mean $PM_{2.5}$ exposure, which was missing for 1.6%, as well as household income and self-reported mental health diagnoses, where missing data was around 10% for each. Missing data ranged 0.4-2.8% for the total scores of multi-scaled instruments. To obtain more accurate estimates, multiple-imputation (MI) procedures (Rubin, 1996) were incorporated in regression analyses using the ICE package (Royston & White, 2011) in conjunction with Stata's inbuilt MI procedures. Imputation was completed using chained equations and 20 datasets were imputed. The total scores

for PSS, 2019-2020 Black Summer concerns, and COVID-19 pandemic concerns were imputed directly. SDQ total difficulties scores were imputed passively by summing the four imputed difficulties domain scores and SEHQ scores were imputed passively by summing individually imputed items.

3.3.3 Descriptive analysis

Descriptive statistics for children represented in the study were categorised according to exposure-type based on group assignments previously established by the ELF research team (early life; in utero; unexposed). This includes assigning some children to the unexposed group based on location diary information indicating they were outside the exposure area for the duration of the mine fire period. Descriptive statistics for responding parents and for families were likewise categorised according to their child's exposure-type, with an additional multiple category defined for parents and families with multiple children across different exposure-types (n = 18) to account for this more complex circumstance. Categorical variables are presented as counts and percentages, and continuous variables as means (*M*) and standard deviations (*SD*). Group comparisons were completed using Fisher's exact test for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. Spearman's rank correlation coefficient (r_s) was used to assess associations between the child outcomes (SDQ total difficulties score; presence of a diagnosed mental health condition) and parent outcomes (K10 score; PSS score) of interest in the study.

3.3.4 Regression modelling

Analysis of child mental health and wellbeing outcomes

Two child mental health outcomes of primary interest were analysed: (1) SDQ total difficulties score and (2) the presence of a diagnosed mental health condition. SDQ total difficulties scoring (a scale continuum outcome) was modelled using multiple linear regression and the presence of a diagnosed mental health condition (a dichotomous categorical outcome with values 1: "Yes"; 0: "No") was modelled using multiple logistic regression; the approach to modelling the exposure and covariates was the same for both outcomes. In line with the exploratory focus of the study, a hierarchical approach to regression analysis was adopted for both outcomes, which facilitated investigation of how the roles of factor-sets changed with the addition of subsequent factor-sets. Table 1 presents an overview of the hierarchical structure for the analyses.

The main exposure metric of interest in these analyses was daily mean physical exposure to mine fire-related $PM_{2.5}$ during the mine fire (whether in utero or in early life), which was measured on a continuous scale with control group participants assigned a default $PM_{2.5}$ exposure level of zero. The presence of a parental mental health diagnosis preceding the mine fire was included as an overarching factor in the regression analyses. An interaction term between parental mental health diagnoses preceding the mine fire and $PM_{2.5}$ exposure during the event was also tested. The interaction was found to be non-significant in each model and was therefore not retained in the final models. All other potential predictors were grouped into three factor-sets (Set 1: Overarching factors; Set 2: Intervening community events; Set 3: Family circumstances) and introduced into the models in a hierarchy of constructs. All factors included in each regression step were carried into subsequent steps so the relevant contribution of each could be observed in the final analysis. The SEHQ includes the item "Mental illness of parent/caregiver" in its list of problems in the family's history, which overlapped with the assessment of parental mental health diagnoses administered elsewhere in the 2022 survey. Accordingly, in preparation for inclusion in all regression analyses, this particular SEHQ item was excluded when categorising the number of problems in the family's history.

Where SDQ total difficulties score was the outcome of interest, a coefficient of determination (R^2) was presented at each step of the hierarchical modelling. Here, R^2 represented the percentage of variance explained in the outcome by regressing on the applicable factor-set. Where diagnosed mental health condition was the outcome of interest, because it was a dichotomous variable, Harrell's Concordance Index (C-index; Harrell et al., 1996) was presented at each step of the hierarchical modelling. The C-index is a measure of concordance between the predicted and observed outcome based on the predictors in the model. The C-index ranges from 0-1 with 0.5 being equivalent to even chance, 0.6-0.7 considered satisfactory, and values over 0.7 considered good.

Analysis of parent mental health and wellbeing outcomes

Two parental mental health and wellbeing outcomes of interest, (1) K10 score and (2) PSS score, were each analysed on a scale continuum. A hierarchical regression approach, similar to that used for the analyses of children's mental health and wellbeing outcomes, was adopted for investigating both outcomes (see Table 1). While the factor-sets for the analyses of parent outcomes were similarly structured to the factor-sets for the analyses of child outcomes, there were some differences between them: in the analysis of child outcomes the child-related factors reflect the individual whereas, in the analysis of parent outcomes, the child-related factors reflect a composition of each of the parent's children in the ELF cohort (e.g., the youngest of their children in the cohort, any of their children in the cohort with First Nations heritage). Multiple linear regression models were used to analyse associations between the amount of mine fire-related $PM_{2.5}$ the child was exposed to and each parental mental health outcome. Parents with multiple children in the cohort were assigned the highest exposure level from among their children in the ELF cohort. The remaining potential risk and confounding factors were included hierarchically in the models in three temporally distinct factor-sets (Set 1: Overarching factors; Set 2: Intervening community events; Set 3: Family circumstances). R^2, representing the percentage of variance explained by regressing on the set of predictors, was applied in the hierarchical modelling for both K10 and PSS score

3.3.5 Sensitivity analysis

The ELF study originally classified children into three primary exposure groups (early life exposure; in utero exposure; unexposed), based on their date of birth relative to the mine fire period. As noted in 3.1.1 above, there were a small number of children with mixed exposure; this group was merged with the in utero exposure group for the analyses. For each mental health and wellbeing outcome of interest in the study (children: SDQ and childhood mental health diagnosis; parents: K10 score and PSS score), a sensitivity analysis was conducted using this exposure classification in place of the daily mean mine fire-related $PM_{2.5}$ exposure estimates used in the main analyses. The unexposed group was treated as the reference category in the sensitivity analyses. For parent outcomes, the additional multiple exposure category was also included.

3.3.6 Final sample

In total, 227 parents of 249 children participated in the 2022 survey. This involved 90 children in the early life exposure group, 100 children exposed in utero, and 59 in the non-exposed control group.

3.4 Human Research Ethics Committee approval

The protocol for the ELF Baseline survey was approved by the University of Tasmania Research Ethics Unit (UTas REU) on 25 May 2015 (project number H0014875) and by the Monash University Human Research Ethics Committee (MUHREC) on 19 June 2015 (project number CF15/2328 - 2015000938). Ethical approval to conduct the 2022 survey was granted by UTas HREC on 30 November 2021 (amendment to project number H0014875) and ratified by MUHREC on 13 December 2021 (project number 31424).

Table 1 Hierarchical Approach to Assessing Factors Associated with Child and Parent Mental Health and Wellbeing

Factor-set	Child mental health and wellbeing	Parent mental health and wellbeing
Set 1: Overarching factors	Mine fire-related $PM_{2.5}$ exposure	Mine fire-related $PM_{2.5}$ exposure of their most exposed child in the cohort
	Parent or caregiver with a mental health diagnosis preceding the mine fire	Parent or caregiver with a mental health diagnosis preceding the mine fire
	Respondent parent or caregiver's age	Respondent parent or caregiver's age
	Postsecondary qualification in the household at baseline	Postsecondary qualification in the household at baseline
	Child's age	Age of their youngest child in the cohort
	Child has First Nations heritage	A participating child has First Nations heritage
	Child had a diagnosed medical condition at baseline	A participating child had a diagnosed medical condition at baseline
	Child's sex	
Set 2: Intervening community events	COVID-19 pandemic concerns score	COVID-19 pandemic concerns score
	2019-2020 Black Summer concerns score	2019-2020 Black Summer concerns score
Set 3: Family circumstances	Annual household income (2020-2021 financial year)	Annual household income (2020-2021 financial year)
	Three or more children in the household	Three or more children in the household
	Single parent or caregiver in the household	Single parent or caregiver in the household
	One or more problems in the family history	One or more problems in the family history
	One or more family challenges affecting the child in previous 12 months	One or more family challenges affecting the child in previous 12 months

4. Results

4.1 Sample characteristics

Tables 2-4 present descriptive statistics, overall and by exposure group, for participating children, parents, and families respectively. Overall, 227 parents completed the 2022 survey in relation to 249 children in the ELF cohort. The sample comprised 207 families (91%) with one child enrolled in the study, two families (1%) with multiple children within the same exposure-type (e.g., twins), and 18 families (8%) with multiple children across different exposure-types (defined in the tables as "Multiple" exposure). Each parent who completed the 2022 survey was the same parent who completed the 2016 ELF baseline survey. The average age of the children during the 2022 survey was 7.6 years (*SD* = 1.0), with 51% female. Almost all were born in Australia with 5% having First Nations heritage. Thirty six percent had a diagnosed medical condition at the time of the 2016 survey with ear, nose and throat conditions being the most common. The average age of participating parents during the 2022 survey was 38.5 years (*SD* = 5.9) with 94% being a biological mother and the remaining 6% being a biological father.

Table 2 Characteristics of Children Whose Parents Participated in the 2022 Survey

		Mine fire exposure-type			
	Cohort	**Early life**	**In utero**	**Unexposed**	
	***n* = 249**	***n* = 90**	***n* = 100**	***n* = 59**	***p*-value**
Age at survey (years)[1, 2]	7.6 (1.0)	8.7 (0.6)	7.4 (0.5)	6.4 (0.5)	
Sex					
Female	126 (51%)	44 (49%)	50 (50%)	32 (54%)	.815
Male	123 (49%)	46 (51%)	50 (50%)	27 (46%)	
Country of birth					
Australia	248 (>99%)	89 (99%)	100 (100%)	59 (100%)	.598
Outside Australia	1 (<1%)	1 (1%)	0 (0%)	0 (0%)	
First Nations heritage[3]					
Aboriginal or Torres Strait Islander	12 (5%)	4 (4%)	5 (5%)	3 (5%)	1.000
Not Aboriginal or Torres Strait Islander	235 (95%)	85 (96%)	94 (95%)	56 (95%)	
Diagnosed medical condition at baseline[3,4]					
No	159 (64%)	53 (59%)	63 (64%)	43 (73%)	.228
Yes	89 (36%)	37 (41%)	36 (36%)	16 (27%)	

[1] Mean and *SD* reported.
[2] Age was not statistically compared as groups were defined by exposure which was based on DoB.
[3] Missing data: First Nations heritage (0.8%); Diagnosed medical condition (0.4%).
[4] Baseline diagnosed medical conditions: The proportions across the cohort were as follows: Asthma (10%); Lung-related conditions (6%); Ear, nose, and throat-related conditions (14%); Heart-related conditions (6%); Other conditions (10%); Children with more than one condition (7%).

In Table 4, it is apparent that most families (81%) had two parents or caregivers in the household, with the other 19% being single parent families. Postsecondary education was around 90% in families of children in the in utero exposure and unexposed groups, significantly higher than it was for the other two exposure groups. Parents in the multiple exposure group tended to vary from parents of children within a single exposure group, being more likely to live in Morwell or have faced an "other" challenging event, and less likely to have post-school qualifications, although participant numbers in this group were low (*n* = 18). No other family characteristics summarised in Table 4 were significantly different across the exposure groups. While there were no clear differences between exposure groups it is interesting to note that a parent or other caregiver mental health diagnosis was present in 39% of families, with the diagnosed condition currently impacting the parent or caregiver's daily functioning in around half of those cases. In

the context of the 2014 mine fire, 23% of families had a parent or caregiver with a mental health diagnosis preceding the event. Thirty-six percent of families had experienced multiple family challenges affecting a participating child in the past 12 months and 16% had multiple problems in their family history.

Table 3 Characteristics of Participating Parents at the Time of the 2022 Survey

		Participating child mine fire exposure-type				
	Cohort	**Early life**	**In utero**	**Unexposed**	**Multiple[1]**	
	***n* = 227**	***n* = 71**	***n* = 89**	***n* = 49**	***n* = 18**	***p*-value**
Age at survey (years)[2]	38.5 (5.9)	40.0 (6.2)	38.0 (4.7)	37.9 (7.4)	36.9 (4.9)	.110
Country of birth						
Australia	207 (91%)	65 (92%)	79 (89%)	48 (98%)	15 (83%)	.127
Outside Australia	20 (9%)	6 (8%)	10 (11%)	1 (2%)	3 (17%)	
Relationship to child						
Biological mother	214 (94%)	64 (90%)	85 (96%)	48 (98%)	17 (94%)	.285
Biological father	13 (6%)	7 (10%)	4 (4%)	1 (2%)	1 (6%)	
Self-reported general health status						
Excellent	7 (3%)	2 (3%)	4 (4%)	1 (2%)	0 (0%)	.584
Very good	61 (27%)	19 (27%)	22 (25%)	16 (33%)	4 (22%)	
Good	101 (45%)	28 (39%)	46 (52%)	16 (33%)	11 (61%)	
Fair	47 (21%)	18 (25%)	14 (16%)	12 (24%)	3 (17%)	
Poor	11 (5%)	4 (6%)	3 (3%)	4 (8%)	0 (0%)	

[1] As noted in 3.3.3, for this table along with Tables 4 and 9, which are focused on parents or the wider family group, there is potential to include information from multiple children in different exposure groups, and so the multiple group hs been added.
[2] Mean and *SD* reported; no missing data.

Table A1 presents a comparison of characteristics between responders and non-responders to the 2022 survey, based on their 2016 baseline survey data. Responders were on average older and, at baseline, were more likely to have postsecondary education, were more likely to have been in paid employment, and were less likely to have been a smoker. 2022 survey response rates were higher among parents of children in the in utero exposure group and lower among parents of children in the unexposed group.

Table 4 Characteristics of Participating Families at the Time of the 2022 Survey

	Cohort	Participating child mine fire exposure-type				
		Early life	In utero	Unexposed	Multiple	
	n = 227	*n* = 71	*n* = 89	*n* = 49	*n* = 18	*p*-value
Number of parents and other caregivers in the household						
Single parent in the household	44 (19%)	7 (14%)	18 (20%)	12 (17%)	7 (39%)	.168
Two parents or caregivers in the household	183 (81%)	42 (86%)	71 (80%)	59 (83%)	11 (61%)	
Number of children in the household[1]	2.5 (1.0)	2.5 (1.0)	2.4 (1.2)	2.4 (0.9)	2.8 (0.9)	.393
Family place of residence in 2022						
Morwell	56 (25%)	20 (28%)	18 (20%)	8 (16%)	10 (56%)	.012
Wider Latrobe City	141 (62%)	37 (52%)	61 (69%)	35 (71%)	8 (44%)	
Outside Latrobe City	30 (13%)	14 (20%)	10 (11%)	6 (12%)	0 (0%)	
Highest level of education among parents and caregivers in the household[2]						
Secondary Year 12 or below	36 (16%)	15 (21%)	10 (11%)	5 (10%)	6 (33%)	.049
Postsecondary qualification	190 (84%)	56 (79%)	78 (89%)	44 (90%)	12 (67%)	
Employment among parents and caregivers in the household[2]						
No parent or caregiver in paid employment	29 (13%)	10 (14%)	11 (12%)	5 (10%)	3 (17%)	.859
One parent or caregiver in paid employment	48 (21%)	17 (24%)	17 (19%)	9 (18%)	5 (28%)	
Multiple parents or caregivers in paid employment	150 (66%)	44 (62%)	61 (69%)	35 (71%)	10 (56%)	
Household income (2020-2021 financial year) [2]						
Below $50,000	39 (19%)	13 (21%)	11 (14%)	8 (17%)	7 (41%)	.355
$50,000 to $99,999	54 (26%)	17 (27%)	21 (26%)	13 (28%)	3 (18%)	
$100,000 or greater	112 (55%)	32 (52%)	48 (60%)	25 (54%)	7 (41%)	
COVID-19 pandemic concerns score[1]	27.76 (7.37)	28.8 (7.2)	27.3 (7.9)	27.6 (7.2)	26.6 (6.0)	.492
2019-2020 Black Summer concerns score[1]	17.19 (6.89)	16.9 (7.1)	17.7 (6.9)	16.7 (6.7)	17.3 (7.1)	.808
Parent or caregiver with a mental health diagnosis in the family[1]						
No	122 (61%)	43 (67%)	46 (60%)	24 (57%)	9 (53%)	.564
Yes, parent or caregivers' current daily functioning not affected by the condition	38 (19%)	7 (11%)	17 (22%)	10 (24%)	4 (24%)	
Yes, parent or caregivers' current daily functioning affected by the condition	40 (20%)	14 (22%)	14 (18%)	8 (19%)	4 (24%)	
Parent or caregiver with a mental health diagnosis preceding the mine fire[1]	47(23%)	10(16%)	19(24%)	12(26%)	6(35%)	.264
Family challenges affecting the child in previous 12 months[1]						
Divorce or separation of parents	14 (6%)	5 (7%)	4 (5%)	3 (6%)	2 (11%)	.641
Death of a relative or friend	55 (24%)	17 (24%)	22 (25%)	12 (24%)	4 (22%)	1.000
Remarriage of parent	5 (2%)	0 (0%)	4 (5%)	0 (0%)	1 (6%)	.087
Serious illness of parent or caregiver	40 (18%)	14 (20%)	17 (19%)	7 (14%)	2 (11%)	.769
Serious illness of sibling	22 (10%)[2]	11 (16%)	7 (8%)	3 (6%)	1 (6%)	.290

	Cohort *n* = 227	Participating child mine fire exposure-type: Early life *n* = 71	In utero *n* = 89	Unexposed *n* = 49	Multiple *n* = 18	*p*-value
Table 4 continued from previous page						
Family challenges affecting the child in previous 12 months (continued)						
Parent or caregiver change of job	72 (32%)	16 (23%)	32 (36%)	15 (31%)	9 (50%)	.100
Parent or caregiver loss of job	23 (10%)	7 (10%)	11 (13%)	4 (8%)	1 (6%)	.853
Move to a new house	37 (16%)	9 (13%)	17 (19%)	7 (14%)	4 (22%)	.610
New baby in the house	25 (11%)	9 (13%)	9 (10%)	6 (12%)	1 (6%)	.886
Other challenging event	15 (7%)	3 (5%)	3 (4%)	5 (11%)	4 (22%)	.028
Number of family challenges affecting the child in previous 12 months						
No family challenges affecting the child	70 (33%)	24 (38%)	28 (33%)	14 (30%)	4 (22%)	.932
One family challenge affecting the child	66 (31%)	18 (28%)	27 (32%)	14 (30%)	7 (39%)	
Multiple family challenges affecting the child	77 (36%)	22 (34%)	30 (35%)	18 (39%)	7 (39%)	
Problems in the family history[1]						
Alcohol or drug-related problems in the family	28 (13%)	10 (14%)	7 (8%)	8 (17%)	3 (17%)	.352
Abuse to a parent or caregiver	23 (10%)	9 (13%)	7 (8%)	6 (12%)	1 (6%)	.687
Child witnessing violence	18 (8%)	4 (6%)	8 (9%)	4 (8%)	2 (12%)	.771
Parent or caregiver witnessing violence	24 (11%)	8 (11%)	9 (10%)	6 (12%)	1 (6%)	.931
Gambling problem in the family	10 (4%)	3 (4%)	3 (3%)	4 (8%)	0 (0%)	.554
Mental illness of a parent or caregiver	69 (31%)	18 (26%)	27 (31%)	17 (35%)	7 (39%)	.605
Other family problem	9 (4%)	4 (6%)	2 (2%)	2 (4%)	1 (6%)	.592
Number of problems in the family history						
No problems in the family history	130 (63%)	45 (70%)	49 (61%)	28 (64%)	8 (47%)	.375
One problem in the family history	43 (21%)	8 (13%)	20 (25%)	9 (20%)	6 (35%)	
Multiple problems in the family history	32 (16%)	11 (17%)	11 (14%)	7 (16%)	3 (18%)	
Family stress rating[1]	2.6 (1.1)	2.5 (1.0)	2.5 (1.1)	2.7 (1.2)	2.8 (0.9)	.703

[1] The following variables had missing data: Education (0.4%); Household income (9.7%); COVID-19 pandemic concerns (0.9%); 2019-2020 Black Summer concerns (0.4%); Parent or carer with a mental health diagnosis (11.9%) or with a mental health diagnosis preceding mine fire (9.3%); Family challenges affecting the child in previous 12 months ranged 0.9%-1.3% except for Other challenging event (5.3%); Problems in the family's history items ranged 0.0%-2.2% except for Other family problem (5.3%); Family stress rating (0.4%).

[2] Mean and *SD* reported.

4.2 Child mental health and wellbeing

Table 5 presents mental health and wellbeing outcomes for children in the study. Mental health and wellbeing outcomes did not significantly differ between children in each of the three exposure-types. The sample-wide mean SDQ total difficulties score was 10.60 (*SD* = 7.25). The highest SDQ difficulties subdomain mean scores was 4.16 (*SD* = 3.12) for Hyperactivity, which was followed by 3.02 (*SD* = 2.65) for Emotional problems. The most common diagnoses across the cohort were an Anxiety Disorder (16%), Attention-Deficit / Hyperactivity Disorder (13%), and Autism Spectrum Disorder (10%); 12% of children had been diagnosed with more than one mental health condition.

Table 5 Child Mental Health and Wellbeing: Exposure Group Comparisons

		Mine fire exposure-type			
	Cohort	**Early life**	**In utero**	**Unexposed**	
	***n* = 249**	***n* = 90**	***n* = 100**	***n* = 59**	
	Mean (*SD*)	**Mean (*SD*)**	**Mean (*SD*)**	**Mean (*SD*)**	***p*-value**
SDQ total difficulties score	10.60 (7.25)	11.1 (7.1)	10.1 (7.2)	10.7 (7.5)	.671
Emotional problems score	3.02 (2.65)	3.4 (2.6)	2.8 (2.7)	2.8 (2.7)	.185
Conduct problems score	1.79 (1.86)	1.7 (1.8)	1.9 (1.8)	1.9 (2.0)	.769
Hyperactivity score	4.16 (3.12)	4.2 (3.2)	4.0 (3.1)	4.3 (3.1)	.794
Peer problems score	1.63 (1.79)	1.7 (1.8)	1.5 (1.7)	1.7 (2.0)	.650
Prosocial behaviour score	8.22 (2.01)	8.3 (1.9)	8.4 (1.9)	7.8 (2.4)	.139
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***p*-value**
SDQ total difficulties score in the high-risk range	59 (24%)	26 (30%)	20 (20%)	13 (22%)	.304
Diagnosed mental health condition					
No	181 (73%)	62 (69%)	74 (74%)	45 (76%)	.598
Yes	68 (27%)	28 (31%)	26 (26%)	14 (24%)	
An anxiety disorder	38 (16%)	16 (18%)	14 (14%)	8 (14%)	.768
A depressive disorder	4 (2%)	1 (1%)	0 (0%)	3 (5%)	NP[2]
A posttraumatic stress disorder	3 (1%)	1 (1%)	0 (0%)	2 (3%)	NP[2]
Attention-deficit / hyperactivity disorder	32 (13%)	11 (13%)	14 (14%)	7 (12%)	.914
Conduct disorder	2 (1%)	0 (0%)	2 (2%)	0 (0%)	NP[2]
Oppositional defiant disorder	2 (1%)	0 (0%)	2 (2%)	0 (0%)	NP[2]
Autism spectrum disorder	25 (10%)	8 (9%)	12 (12%)	5 (9%)	.768
Any other mental health diagnosis	6 (2%)	4 (5%)	2 (2%)	0 (0%)	.199
Multiple diagnosed mental health conditions	30 (12%)	10 (11%)	13 (13%)	7 (12%)	.968

[1] Missing data was 0.8% across SDQ total difficulties and domain scores and ranged 1.2%-3.6% across diagnosed mental health conditions.

[2] NP = Not performed and refers to significance testing not undertaken when there were less than 5 instances of an outcome in the cohort.

Table 6 presents the comparison between SEHQ results for the 2022 survey sample and the 2021 Latrobe City and Victorian results (Victorian Department of Education & Training, 2021). This descriptive comparison indicated that children participating in the study were more frequently at high-risk of emotional and behavioural problems than for the wider Latrobe City and for Victoria. Likewise, the proportions of participating families with problems in their family histories or experiencing high or very high levels of family stress were double the proportion for Latrobe City or the wider state.

Table 6 Child Mental Health and Wellbeing: SEHQ SDQ and Family Issues Results Compared with 2021 Latrobe City and Victorian Data

	ELF cohort (*n* = 249)		Latrobe City (*n* = 769)	Victoria (*n* = 60,256)
	n	%	%	%
Social, emotional, and behavioural difficulties[1]				
SDQ total difficulties scores in the high-risk range	59	24	12	7
Emotional symptoms domain scores in the high-risk range	71	29	10	7
Conduct problems domain scores in the high-risk range	42	17	15	11
Hyperactivity domain scores in the high-risk range	48	19	16	10
Peer problems domain scores in the high-risk range	39	16	10	9
Prosocial behaviour domain scores in the high-risk range	45	18	3	3
Problems in the family history[1]				
Alcohol or drug-related problems in the family	28	13	7	4
Abuse to a parent or caregiver	23	10	9	5
Parent or caregiver witnessing violence	24	11	NDA[2]	NDA[2]
Child witnessing violence	18	8	7	3
Gambling problem in the family	10	4	NDP[3]	1
Mental illness of a parent or caregiver	69	31	16	9
Family experiencing high or very high stress during the previous month[1]	45	20	10	9

[1] Missing data: SDQ domain scores and SDQ total difficulties score (0.8%); Problems in the family history items (0.0%-2.2%); Family stress rating (0.4%).
[2] NDA = No data available because data was not collected on the item.
[3] NDP = No data published because the number of children in the data category was less than 5.

4.2.1 Social, emotional, and behavioural difficulties

Table 7 details the hierarchical multiple linear regression results where SDQ total difficulties score was the outcome of interest; Figure 2 presents the magnitude and direction of coefficients in the final model. There were no significant associations between mine fire $PM_{2.5}$ exposure and SDQ total difficulties score, nor between having a parent or caregiver with a mental health diagnosis preceding the mine fire and SDQ total difficulties score. The magnitude of the effect of having a parent or caregiver with a mental health diagnosis preceding the mine fire decreased when the family circumstances factor-set was introduced to the model. The overarching factor-set accounted for 13.15% of the variance in SDQ total difficulties scores. With the addition of the interim community events factor-set, the variance explained by the model increased to 18.23%, and with the addition of the family circumstances factor-set, the final model explained 23.63% of the variance in SDQ total difficulties scores.

The variables that remained consistently associated with higher SDQ total difficulties scores between the first and final factor sets were the child being male (mean change: +2.54 points; 95% CI: 0.89, 4.19) and the child having First Nations heritage (mean change: +3.69 points; 95% CI: 0.58, 6.80). Conversely, a 10-year increase in the respondent parent's age was associated with a 2.26-point (95% CI: 0.73, 3.79) lower SDQ total difficulties score. A child having a diagnosed medical condition at baseline was associated with higher SDQ total difficulties scores in the overarching factor-set (mean change: +2.49 points; 95% CI: 0.38, 4.60), but this attenuated when subsequent factor-sets were added to the regression. Children aged 8 years during the 2022 survey had a lower mean SDQ score than children aged 6-7 years when the interim community events factor-set was included, but this also attenuated in the final model. The presence of one or more problems in the family's history, which was added in the family circumstances factor-set, was also associated with an increase in SDQ score (mean change: +2.42 points; 95% CI: 0.04, 4.79). Parents' COVID-19 and Black Summer concerns scores were not associated with SDQ total difficulties score in the final model.

4.2.2 Diagnosed mental health conditions

Table 8 presents the hierarchical multiple logistic regression results where diagnosed mental health conditions were the outcome of interest; Figure 3 presents the final model. There was negligible variation in the C-index across the three hierarchical steps of the model. From regressing on the overarching factor-set, child sex being male was consistently associated with greater likelihood of a mental health diagnosis (OR = 2.09; 95% CI: 1.17, 3.76). Having a parent or caregiver with a mental health diagnosis preceding the mine fire significantly increased the odds of a child having a diagnosed mental health condition in the overarching factor-set (OR = 2.08; 95% CI: 1.00, 4.32), but attenuated when subsequent factor-sets were added. Having a postsecondary qualification at baseline had a modest association with increased risk of having a child with a mental health diagnosis in the first and second regression steps, with the highest estimate obtained with the addition of family circumstances factor-set (OR = 2.64, 95% CI: 1.16, 6.01). Mine fire-related $PM_{2.5}$ exposure did not increase the odds of a diagnosed mental health condition being present in any of the steps of the modelling.

Table 7 Child Mental Health and Wellbeing: Hierarchical Regression for SDQ Total Difficulties Scores

	Set 1 - Overarching factors		Set 2 - Interim community events		Set 3 - Family circumstances	
	Mean difference SDQ total difficulties [95% CI]	***p*-value**	**Mean difference SDQ total difficulties [95% CI]**	***p*-value**	**Mean difference SDQ total difficulties [95% CI]**	***p*-value**
Mine fire-related $PM_{2.5}$ exposure (per 10 µg/m³ increment)[1]	-0.12 [-1.05, 0.82]	.805	-0.14 [-1.01, 0.72]	.745	-0.19 [-1.11, 0.74]	.693
Parent or caregiver mental health diagnosis preceding the mine fire	1.45 [-0.94, 3.83]	.232	1.22 [-1.13, 3.56]	.308	0.73 [-1.61, 3.08]	.539
Respondent parent or caregiver's age (per 10-year increment)	-2.03 [-3.56, -0.51]	.009	-2.48 [-3.99, -0.97]	.001	-2.26 [-3.79, -0.73]	.004
Postsecondary qualification in the household at baseline	-0.17 [-2.31, 1.98]	.878	0.62 [-1.65, 2.88]	.594	1.46 [-0.83, 3.75]	.211
Child's sex is male	2.19 [0.45, 3.92]	.014	2.47 [0.79, 4.15]	.004	2.54 [0.89, 4.19]	.003
Child's age in 2022						
6-7 years	*Reference group*		*Reference group*		*Reference group*	
8 years	-2.00 [-4.08, 0.08]	.059	-2.12 [-4.17, -0.08]	.042	-1.68 [-3.76, 0.40]	.112
9-10 years	0.15 [-2.08, 2.37]	.898	0.36 [-1.80, 2.52]	.744	0.33 [-1.80, 2.47]	.757
Child has First Nations heritage	4.04 [0.23, 7.86]	.038	3.28 [-0.31, 6.88]	.073	3.69 [0.58, 6.80]	.020
Child had a diagnosed medical condition at baseline	2.49 [0.38, 4.60]	.021	1.98 [-0.12, 4.07]	.064	1.74 [-0.25, 3.74]	.086
COVID-19 pandemic concerns score (per *SD* increment)[2]			0.97 [-0.14, 2.07]	.086	0.59 [-0.51, 1.70]	.292
2019-2020 Black Summer concerns score (per *SD* increment)[2]			1.02 [-0.16, 2.20]	.090	0.75 [-0.43, 1.93]	.213
Household income (2020-2021 financial year)						
Below $50,000					*Reference group*	
$50,000 to $99,999					-1.79 [-5.34, 1.77]	.323
$100,000 or greater					-3.29 [-6.96, 0.38]	.079
Single parent or caregiver in the household					-1.29 [-4.30, 1.72]	.399
Three or more children in the household					-0.63 [-2.37, 1.10]	.474
One or more family challenges affecting the child in previous 12 months					1.38 [-0.58, 3.34]	.167
One or more problems in the family history					2.42 [0.04, 4.79]	.047
Variance in SDQ total difficulties score explained (R^2, %)	13.15%		18.23%		23.63%	

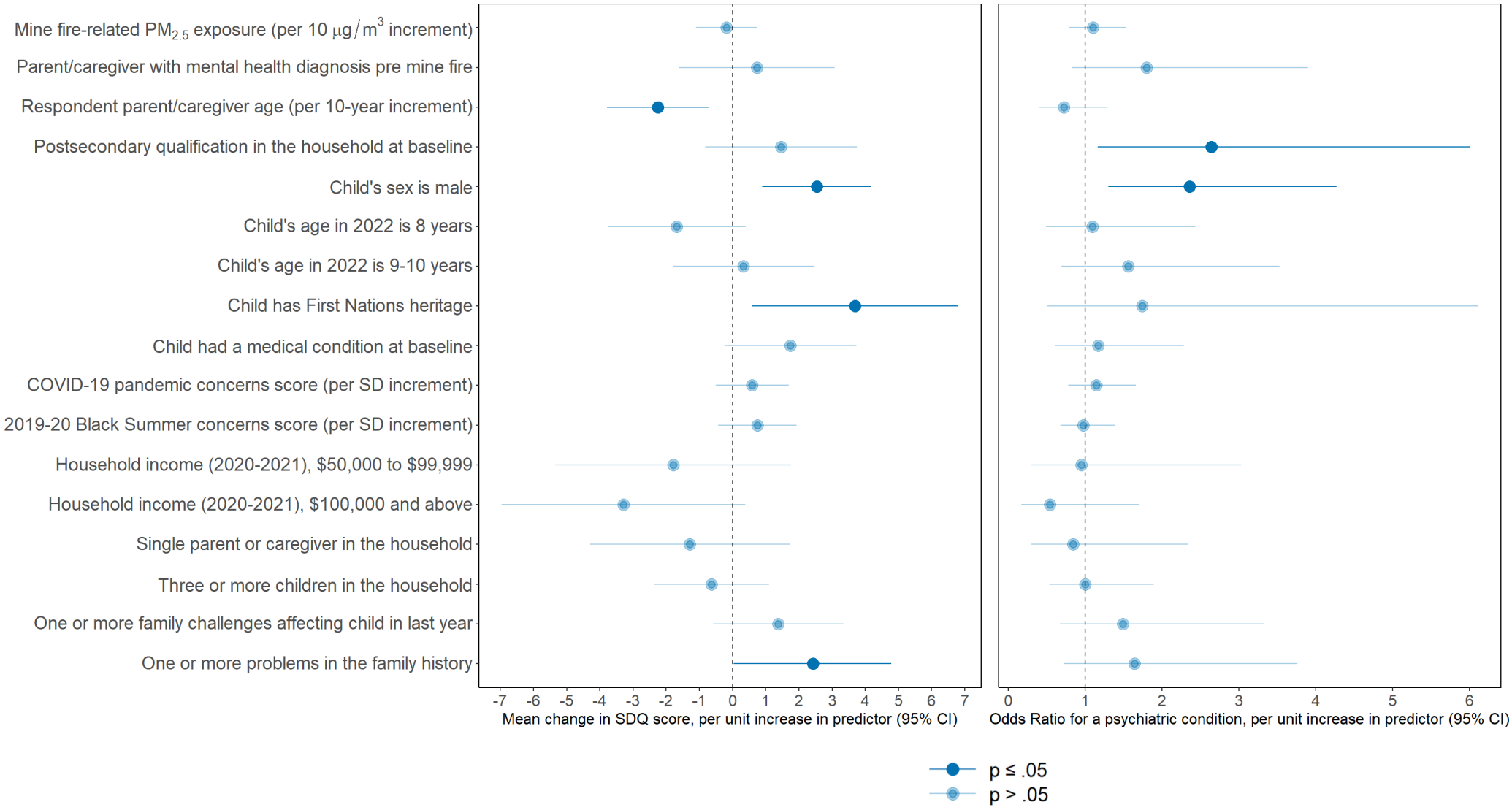
[1] Centred at 10 µg/m³.
[2] Standardised score.

Table 8 Child Mental Health and Wellbeing: Hierarchical Regression for Diagnosed Mental Health Conditions

	Set 1 - Overarching factors		Set 2 - Interim community events		Set 3 - Family circumstances	
	OR for a diagnosed mental health condition [95% CI]	***p*-value**	**OR for a diagnosed mental health condition [95% CI]**	***p*-value**	**OR for a diagnosed mental health condition [95% CI]**	***p*-value**
Mine fire-related $PM_{2.5}$ exposure (per 10 µg/m³ increment)[1]	1.11 [0.80, 1.52]	.536	1.09 [0.79, 1.49]	.595	1.10 [0.79, 1.53]	.572
Parent or caregiver mental health diagnosis preceding the mine fire	2.08 [1.00, 4.32]	.049	1.95 [0.94, 4.03]	.073	1.80 [0.83, 3.90]	.139
Respondent parent or caregiver's age (per 10-year increment)	0.71 [0.41, 1.23]	.223	0.69 [0.40, 1.20]	.189	0.72 [0.40, 1.29]	.265
Postsecondary qualification in the household at baseline	1.96 [0.87, 4.41]	.105	2.06 [0.91, 4.64]	.081	2.64 [1.16, 6.01]	.020
Child's sex is male	2.09 [1.17, 3.76]	.013	2.21 [1.23, 3.97]	.008	2.36 [1.30, 4.27]	.005
Child's age in 2022						
6-7 years	*Reference group*		*Reference group*		*Reference group*	
8 years	0.99 [0.46, 2.13]	.974	0.98 [0.45, 2.10]	.949	1.09 [0.49, 2.43]	.834
9-10 years	1.55 [0.74, 3.27]	.249	1.51 [0.69, 3.29]	.299	1.56 [0.69, 3.53]	.284
Child has First Nations heritage	1.75 [0.49, 6.30]	.390	1.64 [0.47, 5.79]	.441	1.74 [0.50, 6.11]	.387
Child had a diagnosed medical condition at baseline	1.24 [0.65, 2.37]	.511	1.23 [0.64, 2.39]	.535	1.17 [0.60, 2.28]	.652
COVID-19 pandemic concerns score (per *SD* increment)[2]			1.27 [0.89, 1.81]	.191	1.14 [0.78, 1.66]	.510
2019-2020 Black Summer concerns score (per *SD* increment)[2]			0.99 [0.69, 1.42]	.958	0.97 [0.68, 1.39]	.887
Household income (2020-2021 financial year)						
Below $50,000					*Reference group*	
$50,000 to $99,999					0.95 [0.30, 3.03]	.929
$100,000 or greater					0.54 [0.17, 1.70]	.294
Single parent or caregiver in the household					0.84 [0.30, 2.34]	.745
Three or more children in the household					1.00 [0.53, 1.89]	.995
One or more family challenges affecting the child in previous 12 months					1.49 [0.67, 3.33]	.333
One or more problems in the family history					1.64 [0.72, 3.76]	.239
Concordance between the predicted and observed outcome (C-index)	0.67		0.68		0.70	

[1] Centred at 10 µg/m³.
[2] Standardised score.

Figure 2 Child Mental Health and Wellbeing: Overview of Associated Factors



4.3 Parent mental health and wellbeing

Table 9 presents the mental health and wellbeing outcomes for parents in the study. Mental health and wellbeing outcomes did not significantly differ between the different exposure-types. Overall, the distribution of K10 scores indicated 41% of parents were experiencing either high or very high levels of general psychological distress.

Table 9 Parent Mental Health and Wellbeing: Exposure Group Comparisons

		Participating child mine fire exposure-type				
	Cohort ***n* = 227**	**Early life** ***n* = 71**	**In utero** ***n* = 89**	**Unexposed** ***n* = 49**	**Multiple** ***n* = 18**	***p*-value**
General psychological distress (K10 score)[1,2]	21.2 (8.5) [1]	21.3 (8.9)	21.1 (8.4)	21.1 (8.8)	22.0 (7.5)	.978
Low psychological distress	69 (31%)	23 (32%)	26 (30%)	17 (35%)	3 (17%)	.654
Moderate psychological distress	63 (28%)	22 (31%)	23 (26%)	12 (25%)	6 (33%)	
High psychological distress	52 (23%)	11 (15%)	25 (28%)	10 (21%)	6 (33%)	
Very high psychological distress	41 (18%)	15 (21%)	14 (16%)	9 (19%)	3 (17%)	
Parental stress (PSS score)[1,2]	35.8 (9.5)	35.4 (9.9)	35.0 (8.9)	37.0 (9.2)	38.4 (11.0)	.415

[1] Missing data: K10 score (0.9%); PSS score (3.1%).
[2] Mean and *SD* reported.

4.3.1 General psychological distress

Table 10 presents the hierarchical multiple linear regression results where parents' general psychological distress (K10 score) was the outcome of interest; Figure 3 presents the final model. The variance in K10 score explained by the modelling increased from 14.78% at the first step of the model to 33.22% when the interim community events factor-set was added, and increased further, to 38.30%, with the addition of the family circumstances factor-set. The presence of a parental mental health condition preceding the mine fire in the family was associated with a 3.32-point (95% CI: 0.57, 6.07) increase in K10 score and this association was consistent throughout the modelling. Having a postsecondary qualification was associated with lower K10 scoring at the first step of the modelling, but attenuated in subsequent steps. A one *SD* increase in COVID-19 pandemic concern score was associated with an increase in K10 score when the interim community events factor-set was added and remained significant with the introduction of the family circumstances factor-set, where it was associated a 2.55-point (95% CI: 1.45, 3.66) increase in K10 score. The significant association between 2019-2020 Black Summer concern score and K10 score attenuated with the inclusion of the family circumstances factor-set.

4.3.2 Parental stress

Table 11 presents the hierarchical multiple linear regression results for parental stress (PSS score); Figure 3 presents the final model. The variance in PSS score explained by the modelling increased from 6.74% at Set 1 to 11.59% when the interim community events factor-set was added, and to 15.21%, with the addition of the family circumstances factor-set. Having a child with a diagnosed medical condition at baseline was associated with a 3.89-point (95% CI: 1.04, 6.75) increase in PSS score, which was a consistent association across all steps of the modelling. A one *SD* increase in COVID-19 pandemic concerns score was associated with an increase in PSS score when the interim community events factor-set was added, and remained significant with the addition of the family circumstances factor-set, where it was associated with a 2.15-point (95% CI: 0.63, 3.68) increase in PSS score. Having a child affected by one or more family challenges in the previous 12 months was associated with a 3.21-point (95% CI: 0.51, 5.90) increase in PSS score. Mine fire-related exposure of the child was not related to PSS score, nor was having a parent or carer with a mental health diagnosis prior to the mine fire.

Table 10 Parent Mental Health and Wellbeing: Hierarchical Regression for K10 Scores

	Set 1 - Overarching factors		Set 2 - Interim community events		Set 3 - Family circumstances	
	Mean difference in K10 score [95% CI]	***p*-value**	**Mean difference in K10 score [95% CI]**	***p*-value**	**Mean difference in K10 score [95% CI]**	***p*-value**
Mine fire-related $PM_{2.5}$ exposure (per 10 µg/m³ increment)[1]	0.56 [-0.49, 1.60]	.295	0.36 [-0.58, 1.30]	.449	0.15 [-0.83, 1.12]	.766
Parent or caregiver with a mental health diagnosis preceding the mine fire	4.29 [1.58, 6.99]	.002	3.63 [1.04, 6.21]	.006	3.32 [0.57, 6.07]	.018
Respondent parent or caregiver age (per 10-year increment)	-1.19 [-3.06, 0.68]	.210	-1.74 [-3.54, 0.06]	.057	-1.46 [-3.19, 0.28]	.099
Postsecondary qualification in the household at baseline	-3.94 [-7.14, -0.73]	.016	-2.07 [-4.89, 0.74]	.148	-0.81 [-3.58, 1.95]	.562
Youngest participating child's age in 2022						
6-7 years	*Reference group*		*Reference group*		*Reference group*	
8 years	-0.23 [-2.73, 2.27]	.856	-0.62 [-2.88, 1.63]	.587	-0.18 [-2.49, 2.12]	.875
9-10 years	-0.43 [-3.35, 2.48]	.770	-0.50 [-3.06, 2.07]	.704	-0.23 [-2.68, 2.23]	.857
A participating child has First Nations heritage	5.15 [-1.20, 11.49]	.111	3.37 [-3.05, 9.79]	.301	3.71 [-2.22, 9.64]	.219
A participating child had a diagnosed medical condition at baseline	1.42 [-0.89, 3.72]	.228	0.81 [-1.31, 2.93]	.453	0.28 [-1.86, 2.42]	.794
COVID-19 pandemic concerns score (per *SD* increment)[2]			3.02 [1.92, 4.12]	<.001	2.55 [1.45, 3.66]	<.001
2019-2020 Black Summer concerns score (per *SD* increment)[2]			1.28 [0.02, 2.55]	.046	1.12 [-0.17, 2.42]	.088
Household income (2020-2021 financial year)						
Below $50,000					*Reference group*	
$50,000 to $99,999					-2.91 [-6.79, 0.97]	.141
$100,000 or greater					-2.71 [-6.52, 1.10]	.163
Single parent or caregiver in the household					1.70 [-1.72, 5.12]	.329
Three or more children in the household					0.22 [-1.76, 2.20]	.829
One or more family challenges affecting the child in previous 12 months					1.59 [-0.58, 3.75]	.149
One or more problems in the family history					1.77 [-0.91, 4.46]	.194
Variance in K10 score explained (R^2, %)	14.78%		33.22%		38.30%	

[1] Centred at 10 µg/m³.

[2] Standardised score.

Table 11 Parent Mental Health and Wellbeing: Hierarchical Regression for PSS Scores

	Set 1 – Overarching factors		Set 2 – Interim community events		Set 3 – Family circumstances	
	Mean difference in PSS score [95% CI]	***p*-value**	**Mean difference in PSS score [95% CI]**	***p*-value**	**Mean difference in PSS score [95% CI]**	***p*-value**
Mine fire-related $PM_{2.5}$ exposure (per 10 µg/m³ increment)[1]	-0.92 [-2.35, 0.51]	.205	-1.05 [-2.49, 0.40]	.153	-1.20 [-2.63, 0.24]	.101
Parent or caregiver with a mental health diagnosis preceding the mine fire	0.40 [-3.07, 3.86]	.822	-0.27 [-3.76, 3.23]	.880	-0.69 [-4.23, 2.84]	.699
Respondent parent or caregiver age (per 10-year increment)	1.41 [-0.63, 3.45]	.173	1.47 [-0.64, 3.57]	.171	1.62 [-0.45, 3.69]	.125
Postsecondary qualification in the household at baseline	0.50 [-2.72, 3.73]	.759	1.09 [-2.28, 4.45]	.524	1.49 [-2.12, 5.11]	.417
Youngest participating child's age in 2022						
6-7 years	*Reference group*		*Reference group*		*Reference group*	
8 years	-2.10 [-5.23, 1.04]	.190	-2.36 [-5.45, 0.72]	.133	-1.86 [-4.92, 1.20]	.232
9-10 years	-1.96 [-5.22, 1.29]	.235	-2.53 [-5.67, 0.60]	.112	-2.22 [-5.38, 0.94]	.168
A participating child has First Nations heritage	0.66 [-6.91, 8.23]	.864	0.01 [-7.70, 7.72]	.998	0.64 [-7.07, 8.36]	.870
A participating child had a diagnosed medical condition at baseline	4.29 [1.41, 7.18]	.004	4.51 [1.57, 7.45]	.003	3.89 [1.04, 6.75]	.008
COVID-19 pandemic concerns score (per *SD* increment)[2]			2.36 [0.86, 3.85]	.002	2.15 [0.63, 3.68]	.006
2019-2020 Black Summer concerns score (per *SD* increment)[2]			-0.67 [-2.46, 1.12]	.459	-0.87 [-2.68, 0.95]	.348
Household income (2020-2021 financial year)						
Below $50,000					*Reference group*	
$50,000 to $99,999					-2.57 [-7.05, 1.91]	.260
$100,000 or greater					-1.52 [-6.15, 3.12]	.519
Single parent or caregiver in the household					-0.76 [-4.73, 3.22]	.708
Three or more children in the household					0.06 [-2.57, 2.69]	.963
One or more family challenges affecting the child in previous 12 months					3.21 [0.51, 5.90]	.020
One or more problems in the family history					1.56 [-1.79, 4.90]	.360
Variance in PSS score explained (R^2, %)	6.74%		11.59%		15.21%	

[1] Centred at 10 µg/m³.
[2] Standardised score.

Figure 3 Parent Mental Health and Wellbeing: Overview of Associated Factors

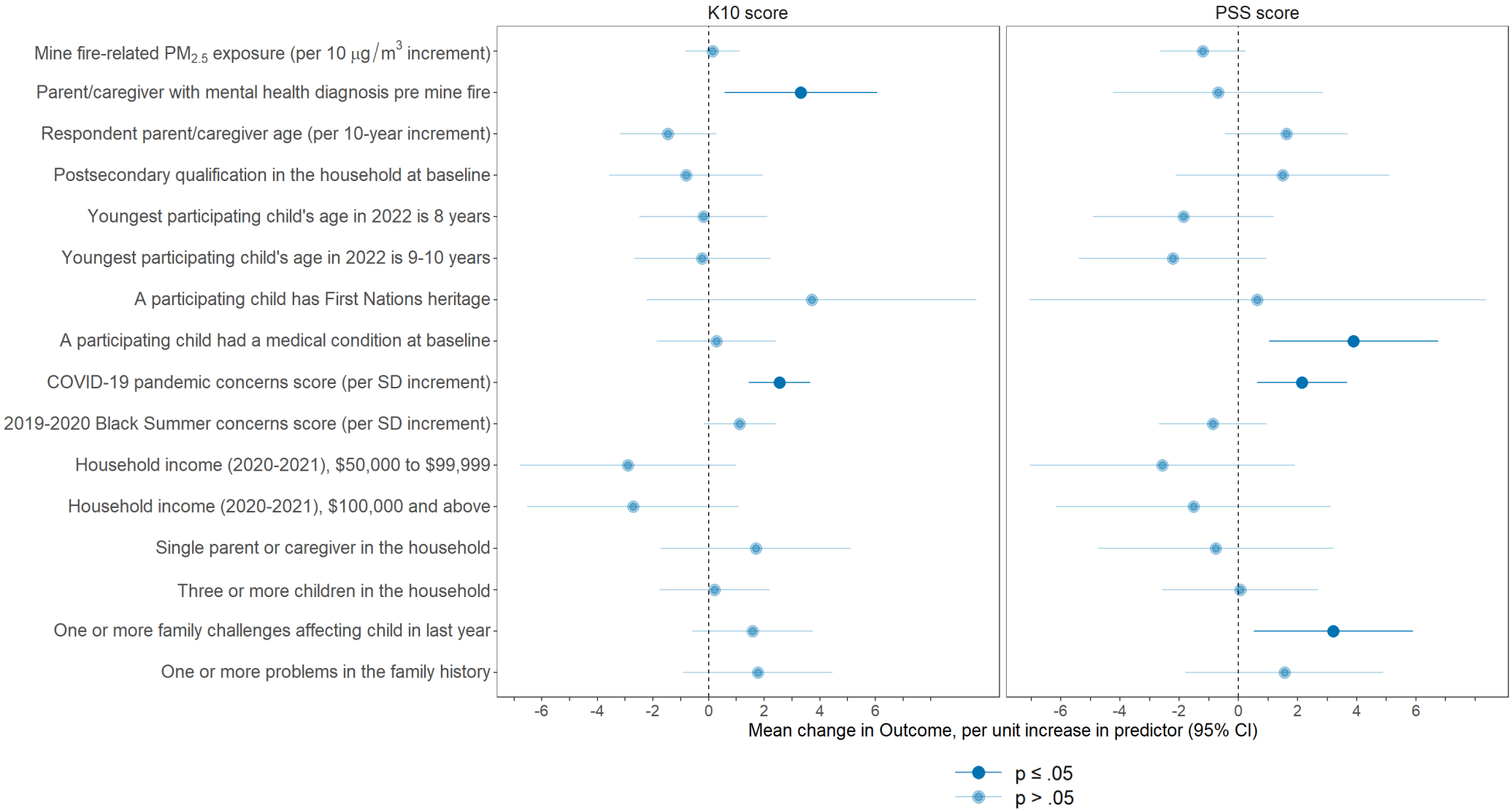


Table A2 presents the associations between the child and parent mental health and wellbeing outcomes investigated in the study. Spearman's rank correlation coefficients ranged 0.20 to 0.44, indicating moderate positive associations between child mental health and wellbeing (SDQ total difficulties score; presence of a diagnosed mental health condition) and parent mental health and wellbeing (K10 score; PSS score).

4.4 Sensitivity analyses

Tables A3 and A4 present results of the sensitivity analyses in relation to child mental health and wellbeing outcomes (SDQ total difficulties score and diagnosed mental health conditions respectively). Tables A5 and A6 present results of the sensitivity analyses in relation to parent mental health and wellbeing outcomes (K10 score and PSS score respectively). The results of each analysis were consistent with the corresponding primary analyses, suggesting study findings can be considered robust.

5. Discussion

5.1 The association between exposure to mine fire smoke and mental health and wellbeing

The present study indicates that there were no significant differences in either child or parent mental health outcomes associated with exposure to smoke from the 2014 Hazelwood mine fire, in either the analyses between exposure groups (early life, in utero, unexposed) or in terms of $PM_{2.5}$ exposure. While there is no clear evidence of a mine fire exposure effect in this analysis, there were indications of high rates of childhood mental health diagnoses, emotional and behavioural difficulties among children, general psychological distress among parents, and problems in the family which will be explored in some detail in the following sections on child and parent mental health and wellbeing.

5.2 Child mental health and wellbeing and the role of family risk factors

Overall, 27% of children whose parent participated in the 2022 survey had a mental health diagnosis, with Anxiety, ADHD, and ASD the predominant conditions. This is more than double the 12.7% estimate for childhood mental health disorder from a recent systematic review of findings from across 11 high-income countries including Australia (Barican et al., 2022). In the responses to the 2022 survey, male children were more likely to have a mental health diagnosis than female children, which is consistent with findings for 4-11-year-old children from the Second Australian Child and Adolescent Survey of Mental Health and Wellbeing (Lawrence et al., 2015) and international research (see Zahn-Waxler et al., 2008) indicating boys are more likely than girls to be diagnosed with an early-onset mental health disorder such as ADHD, ASD, and conduct disorders. Similarly, the finding here that male children had a higher mean SDQ total difficulties score than female children is consistent Victorian and Australia-wide research conducted in these age-groups (see Kremer et al., 2015 and Seward et al., 2018 respectively).

To enable comparison between our school-aged participants and those from across the Latrobe City LGA and the wider state of Victoria, the 2022 survey included two components routinely embedded within the School Entrant Health Questionnaire (SEHQ) – the Family Issues section (which assesses the challenges faced by families in the last year, historical concerns, and current family stress level) and the SDQ which screens for behavioural concerns in children. While statistical hypothesis testing was not undertaken because the SEHQ is conducted on children of approximately 5 years of age upon beginning grade prep whereas the 2022 survey focused on children aged 6-10 years, the differences between the ELF 2022 Survey participants and the broader Latrobe City and Victorian populations are compelling. For example, 24% of children in the study were reported by their parents to be at "high-risk" (based on an SDQ total score ≥ 17), double the proportion reported for Latrobe City and triple that for the entire state, based on the 2021 SEHQ (Victorian Department of Education and Training, 2021). Furthermore, the proportion of the study cohort in the "high-risk" band on the SDQ prosocial domain (18%: indicating children low on positive social behaviours) was also considerably higher than the 3% reported for the Latrobe LGA and the wider state. In addition, 20% of families in the study were experiencing high or very high household stress, which was double the rate for Latrobe and the wider state; the study cohort also consistently reported higher frequencies of each of the family problems presented in the SEHQ. In our analyses, the presence of a problem in the family history was a significant risk factor for higher SDQ total difficulties score whilst, conversely, having a relatively older-aged parent buffered against higher scoring on

the SDQ. Brought together, these findings demonstrated that, relative to the wider Latrobe City as well as nationally and internationally, a disproportionate number of primary school-aged children in our cohort were living in adverse circumstances affecting their mental health. Given the ELF cohort was recruited across Latrobe City, these differences between the 2022 survey sample and the Latrobe LGA and entire state suggest that parents of children with higher levels of mental health concerns, or exposed to more family-related risk factors, were more likely to complete the 2022 survey.

5.3 Parent mental health and wellbeing

Overall, 39% of families participating in the study included a parent with a mental health diagnosis in their history and, in around half of these cases, the diagnosis had a current impact on the parent's functioning. These findings are consistent with data from the 2020-2022 National Study of Mental Health and Wellbeing (NSMHW), where the lifetime prevalence and 12-month prevalence of mental illness were estimated as 40% and 20% respectively (ABS, 2023a). The overall mean K10 score of participating parents (21.2) places the cohort at the cusp of the "high psychological distress" band based on ABS (2012) scoring guidelines, with 41% of parents scoring either high or very high on the measure. These results substantially exceed the 27% of Gippsland respondents in the same category on the 2020-2022 NSMHW (ABS, 2023a). Notably, the K10 mean score for the cohort was also much higher than the corresponding K10 mean (16.7) reported for Latrobe City in the most recent Australian National Health Survey (ABS, 2023b). However, the mean K10 score found here does align with mean K10 scores returned in other branches of HHS research. For instance, the sample-wide mean K10 score in the HHS 2022 Mental Health and Wellbeing Follow-up Survey of adults who were resident in Morwell and exposed to smoke during the mine fire was similarly elevated (mean K10 score = 19.49: Carroll et al., 2024). Having a household income exceeding $100,000 was the single factor identified in this ELF 2022 survey as protective in relation to parents' levels of general psychological distress.

While there are currently no prescribed scoring bands for classifying PSS scores, the overall mean score of participating parents (35.8) is comparable with results in other studies that have utilised the measure with parent-child dyads in normal physical and mental health circumstances (see Louie et al., 2017). Importantly, parents of children with a diagnosed medical condition, or children recently affected by a family challenge such as a relationship breakdown or job loss, were particularly susceptible to higher levels of parental stress in the 2022 survey.

Importantly, having a greater level of concern in relation to the COVID-19 pandemic was associated with higher levels of both general psychological distress and parental stress, which is consistent with broader research into the impact of the pandemic on families (e.g., Chung et al., 2024; Fong & Iarocci, 2020). During the height of the pandemic when social distancing orders were extensively applied across the state of Victoria, the study's parent cohort was periodically burdened with facilitating home-based education for their participating child (as well as any other school-aged children in the family). For the 2022 survey cohort, this corresponded with kindergarten and early-years school grade levels where foundational learning and classroom behaviours are instilled at an age when children have a relatively lower capacity to engage autonomously in learning tasks. Furthermore, two-thirds of participating families had both parents in paid employment at the time of survey, which suggests that many of these families were likely also trying to fulfil multiple employment requirements from home in conjunction with the parental burdens that arose during the COVID-19 pandemic. In this regard, it could be argued that the study's parent cohort were confronted with a particularly intense combination of challenges and competing demands during the COVID-19 pandemic.

The 2022 survey finding that neither level of $PM_{2.5}$ exposure or exposure group were statistically related to parental mental health, and that parents from all exposure groups tended to have more mental health concerns than would be expected from local and state-level data, was in line with the findings above in relation to increased child mental health concerns. This finding was also broadly in line with other HHS research on adult mental health across three survey rounds, where associations were found between mine fire-related $PM_{2.5}$ exposure level and both mine fire-related posttraumatic stress and general psychological distress in 2016-2017 which had attenuated by 2022, whilst a cohort-wide increase in general psychological distress over that same timeframe was evident (Carroll et al., 2024). Additionally, the HHS Community Wellbeing Stream's qualitative research has consistently found that the mine fire evoked early and long-lasting concerns for some people from across Latrobe City, not just those in the southern part of Morwell closest to the mine (Duffy et al., 2017; Yell et al., 2024). Accordingly, the absence of an exposure effect in

the present study likely reflects a combination of factors, including attenuation of individual exposure associations over the longer-term in conjunction with mental health and wellbeing outcomes having been driven by factors broader than smoke exposure levels.

5.4 Strengths and limitations of the research

This research has a number of acknowledged strengths and limitations. A key strength of the research is the attempt to understand the relationship between parent and child outcomes, rather than simply reporting on them as independent outcomes. Another major strength is the focus on longer-term outcomes, in this case some eight years after the event. The approach to estimating smoke exposure at an individual participant level using time-location diaries mapped to $PM_{2.5}$ distribution over the duration of the mine fire, afforded a greater level of precision compared with other methods commonly used to explore effects of air pollution exposure on population health such as the use of area-based estimates alone. Similarly, the attempt to determine the impact of exposures in utero as well as in early life was a major strength of the HHS ELF program of research. Conversely, a limitation of the exposure assessment approach was the reliance on participants' self-reporting their location details, which were completed retrospectively approximately two years after the event and hence are susceptible to recall error and response biases. More generally, self-report health data, such as personal history of physical or mental diagnosis or that of a family member's, can also potentially be affected by these types of issues. Nevertheless, where possible the study utilised a battery of psychometric assessment tools that were well validated and used extensively for research conducted both in Australia and overseas.

The finding that both parents and children in the study tended to have more mental health concerns than expected, based on local, state and international estimates, may indicate a biased sample, with parents more likely to participate if they or their child/ren were experiencing mental health concerns. The sociodemographic profile of families participating in the 2022 survey also suggested a biased sample, with participating families generally more socioeconomically advantaged relative to what we might expect from the wider Latrobe community based on the ABS 2021 Census. For example, 55% of survey respondents reported a household income of $100,000 or over, compared to 37% reporting an income of $91,000 or more in the 2021 census for Latrobe; 87% reported both carers in employment compared to 66% for Latrobe; 84% reported having a carer with a post-secondary qualification compared to 65% for all adults in Latrobe; and 81% reported having two parents/carers compared to 64% for Latrobe (ABS, 2022). Furthermore, parents of children in the unexposed control group of the ELF cohort were significantly less likely to participate in the current survey round than parents of children in the early life and in utero exposure groups (see Table A1). Adjustments for confounding were applied in the regression analyses to address the potential for selection biases associated with participation unduly influencing results (see Table 1); however, given the high frequency of mental health and wellbeing concerns found in the 2022 sample, it may not have been possible to fully control for confounding. While sample biases potentially reduced the capacity to detect a difference between exposure groups, the finding that parents and children in the 2022 survey had greater mental health and wellbeing concerns could in itself reflect ongoing mine fire-related concerns that motivated participation in the survey.

5.5 Conclusions

The sample-wide high rates of childhood mental health diagnoses, emotional, and behavioural difficulties found in the present study do not appear directly attributable to impacts of exposure to smoke emissions from the 2014 Hazelwood mine fire, whether in early childhood or during gestation. However, the differences between this survey sample and that of the wider Latrobe region and populations more broadly, suggest that families facing particular challenges may have been more likely to take up the invitation to respond to a survey on longer-term child and family health and wellbeing outcomes following the mine fire, which may be an indication in itself of ongoing concerns regarding the mine fire. Regardless, the findings presented here strongly indicate that the mental health and wellbeing of children, parents, and families in Latrobe City should be a focus of further investigation and specific intervention.

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7. Appendix

Table A1 Comparison of 2016 Baseline Survey Data Between Responders and Non-Responders in 2022

	Responders	Non-responders	*p*-value
ELF child	***n* = 249**	***n* = 324**	
Exposure group			
Early life	90 (36%)[1]	114 (35%)	.008
In utero	100 (40%)	98 (30%)	
Unexposed	59 (24%)	112 (35%)	
Child's sex is male	123 (49%)	172 (53%)	.400
Respondent parent or caregiver at baseline	***n* = 227**	***n* = 301**	
Parent or caregiver's age (years)[2]	32.8 (5.9)	30.0 (6.4)	<.001
Mother was living in Morwell at the time of the mine fire	76 (33%)	89 (30%)	.345
Respondent parent or caregiver was the biological mother	214 (94%)	281 (93%)	.449
Parent or caregiver has a postsecondary education[2]	158 (70%)	162 (54%)	<.001
Parent or caregiver in paid employment[2]	147 (65%)	147 (49%)	<.001
Parent or caregiver a smoker	28 (12%)	71 (24%)	.001
Multiple parents or caregivers in the household[2]	191 (89%)	226 (81%)	.012
Mother's overall stress level when pregnant[2]			
Was not stressed at all or was hardly ever stressed	81 (36%)	96 (33%)	.215
Was sometimes stressed	115 (51%)	140 (48%)	
Was stressed most or nearly all of the time	29 (13%)	54 (19%)	
Mother's mine fire-related stress[2]			
Overall stress level was not affected by the mine fire	54 (24%)	87 (30%)	.353
Overall stress level was increased a little by the mine fire	92 (41%)	109 (37%)	
Overall stress level was increased a lot by the mine fire	77 (35%)	95 (33%)	
Father's mine fire-related stress[2]			
Overall stress level was not affected by the mine fire	86 (42%)	118 (45%)	.728
Overall stress level was increased a little by the mine fire	67 (33%)	85 (33%)	
Overall stress level was increased a lot by the mine fire	51 (25%)	58 (22%)	

[1] Mean and *SD* reported.

[2] Missing data: Postsecondary education (0.2%); Paid employment (0.4%); Multiple caregivers in household (6.1%); Maternal stress during pregnancy (2.3%); Maternal mine fire-related stress (2.4%); Paternal mine fire-related stress (12.0%).

Table A2 Spearman's Rank Correlation Coefficients for Child and Parent Mental Health and Wellbeing Outcomes

	1	2	3	4
1. Child social, emotional, and behavioural difficulties (SDQ score)	-			
2. Child had a diagnosed mental health condition	0.57	-		
3. Parental stress (PSS score)	0.44	0.22	-	
4. Parental general psychological distress (K10 score)	0.33	0.20	0.31	-

Table A3 Sensitivity Analysis: Child SDQ Total Difficulties Scores

	Mean difference in SDQ total difficulties score [95% CI]	*p*-value
Exposure group		
Unexposed	*Reference group*	
In utero	0.82 [-1.60, 3.24]	.506
Early life	3.65 [-0.43, 7.73]	.080
Parent or caregiver mental health diagnosis preceding the mine fire	0.73 [-1.59, 3.04]	.535
Respondent parent or caregiver's age (per 10-year increment)	-2.31 [-3.82, -0.81]	.003
Postsecondary qualification in the household at baseline	1.54 [-0.70, 3.78]	.176
Child's sex is male	2.62 [0.99, 4.25]	.002
Child's age in 2022		
6-7 years	*Reference group*	
8 years	-3.52 [-6.11, -0.94]	.008
9-10 years	-3.00 [-7.15, 1.16]	.157
Child has First Nations heritage	3.44 [0.31, 6.57]	.031
Child had a diagnosed medical condition at baseline	1.76 [-0.21, 3.74]	.080
COVID-19 pandemic concerns score (per *SD* increment)[2]	0.51 [-0.60, 1.61]	.368
2019-2020 Black Summer concerns score (per *SD* increment)[2]	0.82 [-0.31, 1.95]	.153
Household income (2020-2021 financial year)		
Below $50,000	*Reference group*	
$50,000 to $99,999	-1.32 [-4.73, 2.09]	.447
$100,000 or greater	-2.74 [-6.33, 0.86]	.135
Single parent or caregiver in the household	-1.06 [-4.04, 1.92]	.483
Three or more children in the household	-0.77 [-2.51, 0.97]	.385
One or more family challenges affecting the child in previous 12 months	1.29 [-0.73, 3.30]	.209
One or more problems in the family history	2.65 [0.27, 5.02]	.029

[1] Centred at 10 µg/m^3.
[2] Standardised scores.

Table A4 Sensitivity Analysis: Child Diagnosed Mental Health Conditions

	OR for a diagnosed mental health condition [95% CI]	*p*-value
Exposure group		
Unexposed	*Reference group*	
In utero	1.19 [0.52, 2.73]	.680
Early life	1.41 [0.36, 5.52]	.623
Parent or caregiver mental health diagnosis preceding the mine fire	1.82 [0.84, 3.94]	.131
Respondent parent or caregiver's age (per 10-year increment)	0.71 [0.40, 1.28]	.257
Postsecondary qualification in the household at baseline	2.57 [1.15, 5.75]	.021
Child's sex is male	2.35 [1.30, 4.25]	.005
Child's age in 2022		
6-7 years	*Reference group*	
8 years	0.99 [0.35, 2.81]	.985
9-10 years	1.26 [0.30, 5.28]	.754
Child has First Nations heritage	1.78 [0.50, 6.34]	.375
Child had a diagnosed medical condition at baseline	1.19 [0.61, 2.32]	.613
COVID-19 pandemic concerns score (per *SD* increment)[2]	1.14 [0.79, 1.66]	.482
2019-2020 Black Summer concerns score (per *SD* increment)[2]	0.97 [0.68, 1.38]	.863
Household income (2020-2021 financial year)		
Below $50,000	*Reference group*	
$50,000 to $99,999	0.93 [0.30, 2.91]	.901
$100,000 or greater	0.54 [0.17, 1.69]	.291
Single parent or caregiver in the household	0.85 [0.31, 2.34]	.753
Three or more children in the household	1.00 [0.53, 1.89]	.998
One or more family challenges affecting the child in previous 12 months	1.47 [0.66, 3.26]	.342
One or more problems in the family history	1.64 [0.72, 3.76]	.240

[1] Centred at 10 µg/m^3.

[2] Standardised scores.

Table A5 Sensitivity Analysis: Parent K10 Scores

	Mean difference in K10 score [95% CI]	*p*-value
Child's exposure group		
Unexposed	*Reference group*	
In utero	-0.27 [-3.00, 2.46]	.847
Early life	-0.22 [-2.95, 2.51]	.873
Multiple	-1.31 [-5.09, 2.47]	.494
Parent or caregiver with a mental health diagnosis preceding the mine fire	3.40 [0.66, 6.14]	.015
Respondent parent or caregiver age (per 10-year increment)	-1.48 [-3.21, 0.26]	.095
Postsecondary qualification in the household at baseline	-0.83 [-3.60, 1.94]	.556
A participating child has First Nations heritage	3.76 [-2.03, 9.55]	.201
A participating child had a diagnosed medical condition at baseline	0.34 [-1.80, 2.49]	.752
COVID-19 pandemic concerns score (per *SD* increment)[2]	2.52 [1.40, 3.64]	<.001
2019-2020 Black Summer concerns score (per *SD* increment)[2]	1.13 [-0.17, 2.44]	.087
Household income (2020-2021 financial year)		
Below $50,000	*Reference group*	
$50,000 to $99,999	-3.10 [-6.99, 0.80]	.119
$100,000 or greater	-2.86 [-6.63, 0.92]	.137
Single parent or caregiver in the household	1.81 [-1.66, 5.29]	.304
Three or more children in the household	0.28 [-1.69, 2.25]	.781
One or more family challenges affecting the child in previous 12 months	1.62 [-0.50, 3.75]	.133
One or more problems in the family history	1.70 [-0.94, 4.34]	.206

[1] Centred at 10 µg/m^3.
[2] Standardised score.

Table A6 Sensitivity Analysis: Parent PSS Scores

	Mean difference in PSS score [95% CI]	*p*-value
Child's exposure group		
Unexposed	*Reference group*	
In utero	-1.93 [-5.26, 1.41]	.256
Early life	-2.44 [-5.89, 1.01]	.165
Multiple	0.68 [-4.98, 6.34]	.812
Parent or caregiver with a mental health diagnosis preceding the mine fire	-0.70 [-4.27, 2.87]	.699
Respondent parent or caregiver age (per 10-year increment)	1.56 [-0.52, 3.63]	.140
Postsecondary qualification in the household at baseline	1.87 [-1.79, 5.52]	.315
A participating child has First Nations heritage	0.40 [-7.34, 8.14]	.919
A participating child had a diagnosed medical condition at baseline	3.44 [0.54, 6.33]	.020
COVID-19 pandemic concerns score (per *SD* increment)[2]	2.04 [0.50, 3.57]	.010
2019-2020 Black Summer concerns score (per *SD* increment)[2]	-0.73 [-2.53, 1.08]	.428
Household income (2020-2021 financial year)		
Below $50,000	*Reference group*	
$50,000 to $99,999	-2.03 [-6.60, 2.55]	.383
$100,000 or greater	-1.21 [-6.04, 3.61]	.619
Single parent or caregiver in the household	-0.94 [-5.03, 3.16]	.652
Three or more children in the household	-0.16 [-2.76, 2.45]	.906
One or more family challenges affecting the child in previous 12 months	3.32 [0.57, 6.08]	.018
One or more problems in the family history	1.55 [-1.80, 4.90]	.362

[1] Centred at 10 µg/m^3.
[2] Standardised score.

8. Document History

Version number	Date approved	Approved by	Brief description
1.0	28/02/2025	HHS Senior Project Manager	Submitted to the Department of Health