Hazelwood
HEALTH STUDY

Volume 2

Hazelwood Health Study:

10 Year Review

Summary

Version 1.1

19 September 2024

Contents

i. Foreword

This is the 2nd volume, from a set of three, submitted to the Victorian Department of Health in fulfillment of the Hazelwood Health Study's 42nd contractual milestone. Combined, the three volumes represent an overview of the Hazelwood Health Study's activities and findings in the ten years since the Study's inception on 30 October 2014.

Volume 1. Hazelwood Health Study: 10 Year Review is the primary report, providing an overview of the background to the Study, research questions and further information requested by the Department of Health, governance structure, research streams and methods, key findings, community engagement activities, and the influence of Study findings on policy and practice.

Volume 2. Hazelwood Health Study: 10 Year Review Summary is a high-level summary of the details provided in Volume 1.

Volume 3. Hazelwood Health Study: 10 Year Review Appendices contains all of the Appendices referred to in Volumes 1 and 2, including a list of all previously completed contractual milestones, governance committee memberships, the Study's Outputs Directory, all lay language Research Summaries, and the Study's 2023 Community Flyer.

This work was funded by the Victorian Department of Health. The findings represent the views of the authors and not the views of the Department.

The Hazelwood mine fire, February 2014
Photo courtesy of Keith Pakenham, Country Fire Authority (CFA) Victoria, Australia

ii. Document History

Version Number	Date	Approved By	Brief Description
1.0	19 Sept 2024	HHS Senior Project Manager	Submitted to the Department of Health
1.1	7 April 2025	HHS Senior Project Manager	Previous Section 8 removed. Authorship expanded.

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A large, diverse and dedicated group of academic, clinical and administrative staff from several Institutions have contributed to the Hazelwood Health Study. A full list is provided in Volume 1.

iv. Abbreviations

µg/m³	Micrograms (one-millionth of a gram) per cubic meter
Air NEPM	Ambient Air Quality National Environment Protection Measure
CFA	Country Fire Authority
CO	Carbon monoxide
COPD	Chronic obstructive pulmonary disease
COVID-19	Coronavirus Disease 2019
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ELF	Latrobe Early Life Follow-up Study
EPA	Environment Protection Authority
GDM	Gestational diabetes mellitus
GP	General practitioner
NAPLAN	National Assessment Program - Literacy and Numeracy
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns (thousandths of a millimetre) or less
Ppm	Parts per million
PTSD	Posttraumatic stress disorder
SA1	Statistical Area Level 1

1 Introduction

In February 2014, bushfire embers ignited a series of fires in the Hazelwood open-cut brown coal mine located in the Latrobe Valley, Victoria, Australia. The resulting coal mine fire burned for more than six weeks and led to dense smoke levels across the region, particularly in the adjacent town of Morwell. In March 2014 the Victorian State Government appointed the first of two Hazelwood Mine Fire Inquiries. In May 2014, the Department of Health determined that it was important to learn from the fire by monitoring long-term health and wellbeing impacts on the community, releasing a Request for Tender (Health C3478) for "A long term study into potential health effects from the Hazelwood coal mine fire".

The Tender was awarded to a consortium of academic, clinical and administrative staff from Monash University, the University of Tasmania Menzies Institute for Medical Research, Federation University, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the University of Adelaide. The resulting Hazelwood Health Study commenced on 30 October 2014 and is now in the final year of an initial ten-year contract. This three-volume set of work represents the Study's 42nd contractual milestone. Appendix 1 in Volume 3 includes a complete list of the Study's contractual milestones since inception.

2 Hazelwood Health Study research questions and further requested information

The Tender included research questions and further 'requested information' encompassing key pollutants, suitable comparator populations, clinical and sub-clinical respiratory and cardiovascular conditions, psychological distress and associated sociodemographic factors and exposure levels, birth weight and child development, cancer, impact upon older people, and community wellbeing and rebuilding.

3 Governance

The Hazelwood Health Study adopted a project management governance structure to establish clear policies and procedures and to maximise best practice. A Project Steering Committee, made up of the leads of each of the Study's research streams, provides overall strategic advice for the Study including oversight of research directions. A smaller Project Management Group is responsible for operationalising the Project Plan and ensuring successful completion of contract deliverables.

To ensure that the Study has input and support from scientific experts, clinicians and local community members, a number of key advisory groups were established. A Scientific Reference Group comprises scientific experts in various disciplines relevant to the Study, who provide input into the Study directions. A Community Advisory Committee, in operation from 2015-2020, was

established to ensure that the Study heard directly from, and worked in partnership with, Latrobe Valley community members, health and community service providers and local government. A Clinical Reference Group, also in operation from 2015-2020, provided advice on clinical matters and involved clinicians and representatives from local health service organisations.

In response to a recommendation from the second Hazelwood Mine Fire Inquiry, a Ministerial Advisory Committee was put in place between 2017-2019 to review the Study's scope of work. In 2019 the Committee requested that the Study undertake a strategic overview and develop a revised Project Plan. As part of this review, a decision was made to embed the Study's community and clinical input into existing networks that had wider connections across the region. On this basis, the Latrobe Health Assembly established a Hazelwood Health Study Sub-committee to provide community input. Similarly, the clinical engagement activities were integrated into the regular meeting of the Latrobe/Baw Baw Gippsland Primary Health Network Sub-regional Clinical Council.

In addition to these internal governance structures, the Department of Health's Hazelwood Long term Health Study Contract Committee has ongoing oversight of the Study and meets regularly with the Project Management Group to consider progress, highlights, direction, issues, dissemination of findings and community engagement.

Appendix 2 in Volume 3 lists the Committee and Group memberships.

4 The Hazelwood Health Study research streams

The Hazelwood Health Study set up several distinct research streams in order to address the requirements of the tender. Some streams have completed their activities and some are ongoing. Each stream's aims and methods are very briefly summarised as follows.

4.1 Exposure Assessment

Led by the CSIRO, this completed stream aimed to identify key pollutants, analyse differences in mine fire-related versus background ambient pollutant concentrations, compare pollutant concentrations in Morwell with other areas, and provide exposure fields for fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) across Morwell and the wider Latrobe Valley. Methods included evaluation of air quality measurements made during the fire, chemical analysis of filter samples, calculation of emission ratios, collection of meteorological data and comparisons with similar fire events. The CSIRO also estimated hourly mine fire-related $PM_{2.5}$ concentrations at high resolutions using their air pollution model combined with chemical transport and weather models.

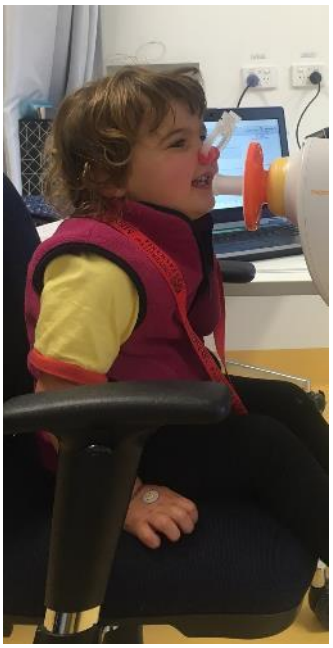
The Hazelwood mine fire, February 2014 Photo courtesy of Keith Pakenham, CFA Victoria

4.2 Adult Survey

Led by Monash University, this completed stream aimed to: investigate the health status of an exposed versus an unexposed comparison adult population using a baseline survey; compare incidence rates of long-term health outcomes by linking survey respondents to administrative health datasets; investigate the association between individual $PM_{2.5}$ exposure level and health outcomes; provide a baseline cohort for other streams to recruit from and which might be drawn upon to answer 'future' research questions. Participants were adults who had resided in Morwell (n=3,096) or selected areas of the comparison community Sale (n=960), at the time of the mine fire. Data were collected by self-report survey and included demographics, general health, medical history, respiratory and psychological symptoms and conditions, occupational exposures, alcohol use and cigarette smoking. Participants completed time location diaries for the mine fire period, which were blended with CSIRO's modelled exposure metrics to estimate individual levels of $PM_{2.5}$ exposure.

4.3 Latrobe Early Life Follow-up (ELF) Study

Led by the University of Tasmania Menzies Institute for Medical Research, this ongoing stream aims to investigate the long-term effects of *in utero,* or early childhood, exposure to Hazelwood mine fire smoke on: perinatal outcomes, particularly foetal growth and maturity; the frequency of parental reports of minor illnesses; long-term respiratory and vascular function; and additional long-term indicators of health and development. Eligible children were born in the Latrobe Valley between 1 March 2012 and 31 December 2015. They comprised 'exposed' children who were either *in utero* or in early childhood (defined as under the age of 2 years) during the mine fire event, or 'unexposed' infants conceived after the event, to allow a gradient of exposures and developmental windows to be examined. The ELF Study established an identified cohort (N=571) and a deidentified cohort (N=3,679) of eligible children.



ELF Study 2017 clinic

The parents of the identified cohort were invited to answer a detailed baseline health survey in regard to their children, complete ongoing symptom diaries, consent to linkage with health and education datasets, and enrol their children in up to three rounds of clinical assessments. Data collection for the deidentified cohort involves linkage to health and educational datasets comprising perinatal, emergency department, hospital admissions, primary healthcare consultations, prescribed medications, cancer, mortality and educational data.

4.4 Psychological Impacts Stream

Led by Monash University, this ongoing stream aims to investigate the: extent of trauma and distress in adults and school-aged children; qualitative perceptions of adults and school-aged children regarding the fire and the ensuing circumstances; impact of the mine fire event on the academic progress of school children; role of individual, family and social factors on recovery and wellbeing outcomes; relationship between community wellbeing and personal wellbeing; and the relationship between parent and child mental health and wellbeing and whether that influences the impacts of the mine fire on child health. The Psychological Impacts Stream comprises two sub-streams: the Schools Study focusing on school-aged children and the Adult Psychological Impacts Stream.

Schools Study participants (N=323) were students who were in grades 3, 5, 7 or 9 in 2015, recruited from 20 schools across the Latrobe Valley. Data collection comprised self-report surveys focused on mine fire-related posttraumatic stress, semi-structured qualitative interviews about the student experiences of the impacts of the mine fire and access to National Assessment Program - Literacy and Numeracy (NAPLAN) test results indicating academic progress. The Schools Study also obtained deidentified NAPLAN results for approximately 10,000 students from 69 schools across the Latrobe Valley and Wellington Shire.

The Adult Psychological Impacts Stream comprised Adult Survey cohort members (N=4,056) of which a subset from Morwell undertook up to two follow-up survey rounds focused on mental health and wellbeing (first follow-up N=709, second follow-up N=519) or semi-structured qualitative interviews (N=27) about their experiences of the impacts of the mine fire.

4.5 Impact on Community Wellbeing Stream

Led by Federation University, this ongoing stream initially aimed to identify community perceptions of: the impact of the smoke event on community wellbeing and resilience; effective communication during and after the smoke event; the effectiveness of community rebuilding activities; and what recovery looks like. Following this, the stream broadened its aims to evaluate how the community's wellbeing and recovery from the mine fire have been impacted by subsequent events and to develop a tool to capture the changes in key dimensions that underpin community wellbeing. The Stream is using both qualitative and quantitative research methods to address its research aims,

with data drawn from: semi-structured interviews with key stakeholders, informants, media professionals and social media practitioners; participatory action research; community focus groups; mainstream media, social media and government agency reports; and publicly available health and community datasets.

4.6 Policy Review of the Impact on Older People

Led by Monash University, this completed stream aimed to assess the impact of the smoke event on older people, review policy decisions made with respect to older people and inform best practice for future emergency events. Data collection included: focus group discussions with older people; interviews with local decision-makers and representatives of services engaged in supporting older people; a literature review on older people and disasters; and a review of key emergency management policies in Victoria.

4.7 Cardiovascular Stream

Led by Monash University, this stream includes a completed clinical sub-study and an ongoing data linkage sub-study. The clinical sub-study aimed to determine whether mine fire smoke exposure was associated with blood pressure, abnormal electrocardiographs, vascular function and inflammatory markers. Participants were 498 members of the Adult Survey cohort who underwent clinical assessments. Data collected included medical history, medications, cigarette smoking, alcohol use, physical activity, dietary habits/food frequency, medications, vascular function, electrocardiograph, biometrics, blood pressure and cardiovascular-related blood markers. The data linkage sub-study is an ongoing collaboration with Hazelinks to monitor cardiovascular events using administrative health datasets.

4.8 Respiratory Stream

Led jointly by Monash University and Alfred Health Respiratory Medicine, this ongoing stream aims to determine whether exposure to smoke from the Hazelwood mine fire is associated with respiratory symptoms, asthma control, lung inflammation, rate of decline in lung function, gas transfer, small airway function and lung mechanics. Participants comprise Adult Survey cohort members who undertook Round 1 (N=519), Round 2 (N=329) and/or Round 3 (N=318) clinical assessments.

2021 Respiratory Stream clinic

Collected data includes: respiratory symptoms and medications; asthma history; allergen exposure; smoking history; fraction of exhaled nitric oxide; spirometry; respiratory system resistance and reactance; small airways function; gas exchange; blood haemoglobin; and COVID-19 antibodies.

4.9 Long-term Respiratory Health Follow-up

Led by Monash, this ongoing stream aims to investigate whether: mine-fire smoke exposure predicts poorer respiratory health in the long-term; effects are moderated by previous COVID-19 infection, the 2019-2020 Black Summer bushfires or dietary quality; smoke exposure from the mine fire or the 2019-2020 Black Summer increased the risk of COVID-19 infections; and whether diet quality is associated with slower deterioration in lung function in people with high mine-fire smoke exposure. Participants comprise 612 Adult Survey cohort members who self-reported respiratory symptoms and conditions, COVID-19 related symptoms, diagnoses and/or hospitalisations, exposure to smoke from the 2019-2020 Black Summer bushfires and dietary food frequency.

4.10 Hazelinks, including Cancer Stream

Led by Monash University, this ongoing stream aims to utilise routinely collected medical services, pharmaceutical, ambulance, hospital, cancer and death registry datasets in order to identify Study participants, and members of the community, who access health services and medications, and/or develop cancer, or respiratory, cardiovascular or psychological conditions, or who die. This includes identified data linked to consenting Adult Survey Cohort members and deidentified, population-wide data.

5 Overview of Hazelwood Health Study findings

The Hazelwood Health Study has made numerous findings and has utilised diverse methods to disseminate those findings to a wide range of audiences. The Study's Outputs Directory (see Volume 3 Appendix 3) provides links to all technical reports, scientific manuscripts, conference proceedings, videos, exhibits, lay language Research Summaries (see Volume 3 Appendix 4) and Annual Reports. This Summary presents only a broad overview of the Study's key findings. For in-depth descriptions and discussions of the findings, refer to Volume 1 of this report series and also the Study's scientific manuscripts and technical reports.

5.1 Key pollutants

- Because the fire was most intense during the initial two days before air monitoring had commenced, it was considered likely that the highest smoke concentrations were not directly measured.
- Subsequent direct measurements in southern Morwell during the mine fire period showed the maximum hourly averaged $PM_{2.5}$ concentration to be 1349 micrograms per cubic meter (µg/m³) and the maximum daily averaged concentration to be 731 µg/m³; almost 30 times the 25 µg/m³ Ambient Air Quality National Environment Protection Measure (Air NEPM), and three to four times greater than the community Smoke, Air Quality and Health standard for $PM_{2.5}$ category of 'Extremely poor'.
- During the mine fire, Environment Protection Authority (EPA) Victoria recorded its highest 8-hour average carbon monoxide (CO) concentration ever measured, peaking at 33 parts per million (ppm) in southern Morwell; almost four times the corresponding CO Air NEPM standard.
- Modelled air pollution data estimated that, during the early days of the fire in southern Morwell, the hourly averaged concentration of $PM_{2.5}$ reached as high as 3,730 µg/m³ and CO reached 58.6 ppm. The daily averaged $PM_{2.5}$ Air NEPM standard of 25 µg/m³ was exceeded on 23 days in southern Morwell, 12 days in eastern Morwell, 5 days in Traralgon, 3 days in Churchill and 2 days in Moe. The CO Air NEPM standard was exceeded on 8 days in southern Morwell, 1 day in eastern Morwell and not elsewhere.
- During the mine fire, modelled $PM_{2.5}$ exposure concentrations varied greatly across days and locations. Adult Survey and ELF Study participants completed a diary with their residential, work and any relocation addresses for each day and night of the mine fire period. Modelled high resolution hourly $PM_{2.5}$ estimates were then blended with the diary data to give each participant a mine fire-related $PM_{2.5}$ exposure level for every 12-hour day and night of the mine fire period.

5.2 Respiratory health in adults

Using deidentified population-wide medical services, pharmaceutical, ambulance, hospital and death registry databases

- During the mine fire period, small increases in smoke exposure levels were associated with 25% increases in dispensing of respiratory medications and, among men, 37% increases in respiratory health-related consultations.
- During the mine fire period, there were approximately 37 additional respiratory-related ambulance attendances. Increases in smoke levels were followed by increases in ambulance attendances for respiratory conditions for about 5 days.

- During the mine fire period, increases in smoke levels were associated with increases in emergency presentations and hospital admissions for chronic obstructive pulmonary disease (COPD) combined with asthma, and with increases in emergency presentations for 'all' respiratory diseases.
- During the 6 months after the fire, there was no observed increase in risk of death from respiratory conditions.
- During the first 8 years after the fire, there were no changes in respiratory-related ambulance attendances, emergency department presentations and hospital admissions in Morwell compared with before the fire and compared with trends in the rest of regional Victoria.

Using identified data linked to, or collected from, Adult Survey and Respiratory Stream participants

- Approximately 2.5 years after the fire, smoke exposure was associated with increased respiratory symptom reporting; particularly cough, phlegm and wheeze.
- Approximately 3.5 years after the fire, mine fire smoke exposure was associated with increased chest tightness, chronic cough and reduced lung stretchiness. Amongst non-smokers, exposure was associated with increased features of COPD. Amongst smokers, exposure was associated with chronic cough.
- Approximately 3.5 years after the fire, in people with asthma exposed to the mine fire smoke compared to those unexposed, there was some evidence of poorer asthma control.
- Small increases in smoke exposure levels were associated with 21% increases in respiratory-related ambulance attendances over a 3.5-year period.
- Small increases in smoke exposure levels were associated with 10% increases in respiratory-related emergency department visits and, among women, 9% increases in hospitalisations over a 5-year period.
- Approximately 7.5 and 9 years after the fire, previously observed associations between mine fire smoke exposure and poorer lung function were no longer evident, suggesting recovery.

2021 Respiratory Stream clinic

5.3 Cardiovascular health in adults

Using deidentified population-wide medical services, pharmaceutical, ambulance, hospital and death registry databases

- During the mine fire period, small increases in smoke exposure levels were associated with 10% increases in dispensing of cardiovascular medications.
- During the mine fire period, there were no increases in visits to cardiovascular health specialists/services, ambulance attendances, emergency presentations or hospital admissions for cardiovascular conditions.
- In Morwell, during the 6 months after the fire, there was a 62% increase in risk of death from cardiovascular conditions.
- During the 8 years after the fire, in Morwell there was an overall decrease in cardiovascular-related ambulance attendances but also an overall increase in cardiovascular-related emergency department presentations and hospital admissions, compared with before the fire and compared with trends in the rest of regional Victoria.

Using identified data linked to, or collected from, Adult Survey and Cardiovascular Stream participants

- Approximately 2.5 years after the fire, mine fire smoke exposure was associated with increased self-reporting of high blood pressure and ‘heart attacks’, however, numbers of cases were very small.
- During the first 3.5 years after the mine fire, small increases in smoke exposure levels were associated with 13% increases in ambulance attendances for cardiovascular conditions.
- Small increases in smoke exposure levels were associated with 10% increases in cardiovascular-related emergency department visits during the first 2.5 years. There were no observed changes in cardiovascular-related hospital admissions in the 5 years following the mine fire.
- Approximately 3.5 years after the fire, there were no differences between exposed and unexposed adults in markers of underlying cardiovascular disease, reduced heart function, heart muscle damage, irregular heart rhythms or blood vessel health.
- A diet high in vegetables, grains, fresh meat and non-fried fish was associated with better

2017 Cardiovascular Stream clinic

cardiovascular health, while soft drinks were associated with poorer cardiovascular health.

5.4 Health in smoke-exposed pregnant women, babies *in utero* and young children

Among women who were exposed to mine fire smoke during pregnancy

- There was a dose-response association between increasing smoke exposure, increased incidence of gestational diabetes mellitus (GDM), particularly when exposure was during the 2nd trimester, and increased birth weight in babies born to smoke exposed mothers with GDM.

Among the babies exposed to mine fire smoke while in utero

- *At birth:* No association between mine fire smoke exposure and overall indicators of foetal growth and maturity, including birthweight at term, being small or large for gestational age, pre-term delivery and gestational age at delivery.
- *First year of life:* No association between smoke level and general practitioner (GP) visits or dispensing of prescribed medications used to treat asthma, atopic dermatitis or bacterial infections. However, there was a dose-response association between increasing smoke exposure and increased presentations to the emergency department for allergies or skin rash, but not for other respiratory or infectious causes and no increases in hospital admissions.
- *First 2 years of life:* There was a dose-response association between increasing smoke exposure and increased dispensing of medications commonly used to treat croup and asthma.
- *2 - 4 years after the fire:* There was a dose-response association between increasing smoke exposure and increased parent-reported cough, wheeze, health service visits and doctor-diagnosed upper respiratory tract infections, cold and flu.
- *3 years after the fire:* No association between smoke level and any markers of vascular stiffness or thickness.
- *7 years after the fire:* There was a modest dose-response association between increasing smoke exposure and small increases in vascular stiffness. There was no association with lung function, or with allergic sensitisation, although statistical power was limited.

Among the infants exposed to mine fire smoke between birth and the age of two years

- *First year post fire:* In the identified cohort (n=121) there was a dose-response association between increasing smoke exposure and increased dispensing of prescribed antibiotics, but no association with GP visits or dispensing of prescribed asthma inhalers or steroid containing skin creams. In the deidentified cohort (n=1,832) there was a dose-response association between increasing smoke exposure, GP visits and increased dispensing of prescribed antibiotics. In a deidentified cohort restricted to those exposed to the smoke between birth and one year of age

(n=861) exposure was associated with increased emergency department presentations for any respiratory cause, and for respiratory infectious conditions, but not with hospital admissions.

- *Second year post fire:* In the deidentified cohort (n=1,832) there was a dose-response association between increasing smoke exposure and increased dispensing of steroid containing creams commonly used for eczema.
- *2 - 4 years post fire:* There was a modest dose-response association between increasing smoke exposure and increased parent-reporting of cough, runny nose and use of inhaled medications for asthma or wheeze.
- *3 years post fire:* There were modest dose-response associations between increasing mine fire smoke exposure and small increases in both lung and vascular stiffness. When the *in utero* and infant-exposed children were combined, there was an association between mine fire exposure and increased vascular stiffness among those whose mothers smoked during pregnancy.
- *Up to 5 years post fire:* Higher category of smoke exposure was associated with increased all-cause emergency department presentations over the 5 years, but not when emergency department presentations were divided into 'infectious causes'; 'respiratory causes'; and 'allergies/skin rashes', and there was no association with hospital admissions.
- *7 years after the fire:* The previously observed associations between smoke exposure, lung stiffness and vascular stiffness after 3 years, were no longer evident after 7 years, suggesting recovery. No association was found between smoke exposure and allergic sensitisation, however, statistical power was limited.

2017 ELF Study clinic

Important results from the early childhood studies not directly related to mine fire emissions

- Independently from exposure to the mine fire smoke, early life exposure to background sources of $PM_{2.5}$ was associated with increased dispensing of antibiotics, GP presentations, emergency department presentations, infection-related hospital admissions and sensitisation to dust.
- Approximately a third of children had a mother who smoked in pregnancy and/or lived in a house with a smoking adult and/or unflued gas heater.
- Maternal smoking during pregnancy was associated with lower birth weight and babies being small for gestational age.
- Maternal smoking during pregnancy/second-hand smoke exposure in the home was independently associated with markers of stiffer lungs and thicker carotid arteries (an early sign of the development of atherosclerosis) in Round 1 clinic participants.
- Maternal stress in pregnancy was associated with a higher risk of pre-term birth and lower birthweight.

5.5 Psychological health and academic progress in school aged children

- At the time of the mine fire, specialist school personnel and students experienced particular difficulties including anxiety, frustration, difficulty adjusting to the relocation environment, reduced sense of safety and declines in attendance and schoolwork.
- Approximately 1.5 years after the mine fire, 22% of surveyed students reported mine fire-related posttraumatic stress symptoms such as heightened alertness, poor sleep, feeling on edge and intrusive thoughts, indicating possible posttraumatic stress disorder (PTSD). On average, Morwell students reported more mine fire-related posttraumatic stress symptoms than non-Morwell students. Primary school-aged students, regardless of their distance from the smoke event, reported more posttraumatic stress symptoms than secondary students. By the time of a follow-up survey two years later, posttraumatic stress levels had generally reduced.
- In interviews conducted in 2015 and 2017, the majority of mainstream school students reported few or no ongoing mine fire-related concerns and had ‘moved on’ from the event. However, some continued to report symptoms consistent with PTSD.
- NAPLAN data linked to 303 Schools Study participants showed that Morwell students had poorer academic performance than non-Morwell students before the mine fire, approximating a 6-11 month delay in academic progress. After the mine fire, however, a substantial 18.5 month further delay in academic progress was observed in secondary (grade 7 and 9) students from Morwell schools, which was not observed in non-Morwell secondary students.

- Victoria-wide deidentified NAPLAN data showed major academic interruptions occurred at Morwell schools across all NAPLAN learning domains in the aftermath of the mine fire. Compared to the Victorian regional average, this interruption equated to a 4 to 5 month delay in academic progress recorded by Morwell school students, which still had not fully recovered several years later.

5.6 Psychological health in adults

Using deidentified population-wide medical services, pharmaceutical, ambulance, hospital and death registry databases

- During the mine fire period, small increases in smoke exposure levels were associated with 32% increases in mental health-related medical consultations among men, and 12% increases in dispensing of psychiatric medications.
- During the mine fire period, small increases in smoke exposure levels were associated with 38% increases in ambulance attendances for anxiety. In the following eight years, there were no changes in mental health-related ambulance attendance rates in Morwell or the Latrobe Valley compared with before the fire and compared with service use trends in the rest of regional Victoria.
- During the mine fire period, small increases in smoke exposure levels were associated with 36% increases in emergency department presentations for depression. In the following eight years in Morwell, compared with before the fire and with service use trends in the rest of regional Victoria, there was a 10% increase in mental health-related emergency department presentations and a 46% increase in mental health-related hospital admissions. Increases were most prominent during the first three years

Using identified data linked to, or collected from, Adult Psychological Impacts Stream participants

- Higher smoke exposure was not associated with higher rates of mental health-related ambulance attendances over a 3.5-year period.
- Higher smoke exposure was not associated with higher rates of mental health-related emergency department visits or hospitalisations over a five-year period.
- Approximately 2.5 years after the mine fire, moderate levels of both mine fire-related posttraumatic stress and general psychological distress were reported by adults in Morwell, and the levels of each increased in line with levels of smoke exposure. Vulnerable groups included younger adults and those with pre-existing respiratory or mental health conditions. Approximately 10% of Morwell adults reported mine fire-related posttraumatic stress symptoms indicating possible PTSD.
- Some adults interviewed in 2016 reported symptoms consistent with PTSD. Adults with pre-existing mental health conditions were particularly vulnerable.
- Approximately 5.5 years after the mine fire, the first follow-up survey of Morwell participants showed a small but significant increase in mine-fire related posttraumatic stress across all smoke exposure levels, particularly in relation to intrusive symptoms and particularly among younger adults. Intrusive thoughts may have been activated or exacerbated by the smoke from the 2019-2020 Black Summer bushfires and associated media coverage which occurred during the data collection period.
- Resilient participants, with low levels of distress at 2.5 and 5.5 years after the fire, on average had higher levels of social support and socioeconomic advantage. Participants with delayed-onset (low at 2.5 years but high at 5.5 years) or chronic posttraumatic stress (high at both times) were more likely to have adversities such as prior trauma, recent stressful life-events or diagnosed physical or mental health conditions.
- Approximately 5.5 years after the mine fire, higher levels of both mine fire-related posttraumatic stress and general psychological distress were observed to be associated with physical (somatic) symptoms. Common symptoms were fatigue, limb pain, trouble sleeping, back pain, headaches and shortness of breath.
- Approximately 5.5 years after the mine fire, Morwell participants reported being somewhat dissatisfied with their community, and that their satisfaction with community had deteriorated since the mine fire. Multiple recent adverse life-events, somatic symptoms and being younger predicted more negative perceptions of community wellbeing. Furthermore, between 40% and 54% of Morwell participants reported experiencing recent loneliness, a physical health diagnosis, a mental health diagnosis, multiple traumatic events and/or recent stressful events.

- Approximately 8.5 years after the mine fire, surveyed Morwell participants reported that mine fire-related posttraumatic stress had largely dissipated. However, general psychological distress was rising across the cohort. Being unemployed or unable to work, having a physical diagnosis (cardiac, asthma or COPD), having a prior mental health diagnosis or lifetime exposure to other traumatic events were all associated with greater levels of general psychological distress.

5.7 Cancer in adults

Population-wide cancer rates before the mine fire

Before the mine fire, the overall rates of cancer in Latrobe City and surrounding areas were similar to the overall rate of cancer in the rural and regional Victorian population. However, when cancers were divided by type, males in Latrobe City were more likely than males in other rural and regional Victorian areas, to have mesothelioma (a cancer caused by asbestos exposure) and bladder cancer, but less likely to have colon cancer. Also, females in Latrobe City were more likely than females in other rural and regional Victorian areas, to have liver, lung or blood cancer, but less likely to have melanoma.

Population-wide cancer incidence up to 7.5 years after the mine fire

We found no change from before to after the fire, in the overall yearly trend of new cancer cases in Morwell or the rest of the Latrobe Valley. When cancers were divided by type, we found that annual incidence of blood cancers decreased (improved), however, we do not believe that the mine fire smoke had a preventive effect leading to this improvement. Annual incidence of lung cancer increased, however, evidence for this was weak. There were no changes in cancer incidence believed to be mine fire-related.

Population-wide cancer survival up to 5.5 years after the mine fire

We found no change from before to after the fire, in the overall monthly pattern of cancer survival in Morwell and the rest of the Latrobe Valley. When cancers were divided by type, we found that survival was shorter after the fire for females in Morwell who had reproductive organ cancers. However, there were only 27 cases in Morwell and, with such small numbers, it was likely that this was a chance finding not due to the mine fire. There were no other changes in cancer survival believed to be mine fire-related.

Adult Cohort: cancer incidence up to 5.5 years after the mine fire

Among Adult Cohort members, a 67% higher risk of overall cancer was observed in Morwell compared with Sale 5.5 years post mine fire, but there was no evidence to suggest that this was related to level of exposure to mine fire smoke. When new cancers were divided by type there were no differences between Morwell and Sale, and no evidence of mine fire-related effects.

Adult Cohort: cancer incidence up to 8 years after the mine fire

Amongst Adult Cohort members, when new cancers were divided by type, there was no evidence of mine fire-related effects.

It is generally considered that our longest available follow-up period of 8 years is likely too short to confidently assess long latency cancers following mine fire smoke exposure. Further, cancer diagnoses in socioeconomically deprived areas tend to lag behind wealthier areas, plus COVID-19-related restrictions likely delayed cancer diagnoses further. Follow-up over a longer time period is necessary to confidently assess the impact of mine fire smoke exposure on cancer.

5.8 Impact on older people

- The voices of older people, especially those usually robust older people living independently in the community, were paid little attention during the event.
- There was little support for older people who were not receiving health and community services.
- Engagement focused on information provided via fact sheets and alerts rather than two-way engagement, leading to confusion, mixed messaging and mistrust.
- There was a mismatch between existing policies, and the extended and dynamic nature of the Hazelwood smoke event prompted policy on the run which further eroded trust.
- Lack of a strong evidence base for short- and long-term health impacts from coal mine fires hampered the public health response.
- It is critical that future policy development and program planning requires careful consideration around: who is delivering information; how information is delivered; who is being targeted; and how to communicate to build and maintain confidence and trust.

5.9 Impact on community wellbeing and community rebuilding

5.9.1 Community wellbeing and rebuilding (Phase 1)

There was a notable loss of trust in the authorities which were dealing with the crisis. Factors leading to the loss of trust included that:

- official communication was perceived to be flawed, at times non-existent, not reflecting the community's experiences nor meeting their needs;
- an emergency management plan seemed to be lacking and coordination between authorities was perceived as poor;

- government, authorities and mine owners GDF Suez were perceived as not accepting responsibility nor being held accountable for what happened.

Local social media were important in filling communication gaps and empowering the community to self-organise and demand answers to their questions and concerns. However, some questioned the authority of social media groups to speak on the behalf of other community members.

The development of a new emergency management plan will be complex but essential to recovery. The plan should include: clear lines of responsibility; trusted, accessible and effective communication channels; and appropriately qualified and experienced leaders.

The concept of 'recovery' needs to involve the development of a long-term vision for Morwell and the Latrobe Valley, including community wellbeing and job creation and sustainability in the context of the transition from coal and the closure of its mines.

Hopes for the future include social connectedness and supports, diversity, dignity and respect for others, resilience, having a voice, appropriate resources for physical and mental health, a stronger economy and greater employment, a smooth transition towards alternative energy industries, and energy security for the Valley.


Stock image

5.9.2 Community wellbeing and rebuilding (Phase 2)

Quantitative Community Wellbeing Barometer data for the period 2008-2023, show:

- most *economic* measures in the Latrobe Valley were trending upward;
- an upward trend in the *environment* domain, although considerable annual variation across measures;
- a general downward trend in the *health* domain, although the most recent data (2021) indicates a return (rise) to the previous average;

- a general upward trend in the *services and infrastructure* domain;
- a slight upward trend in the *social connections* domain;
- changes in the *environment*, *services and infrastructure*, and *social connections* domains may be explained by events such as fires, the pandemic, or government interventions;
- The overall community wellbeing trend shows wellbeing falling to 2016, then rising. Relative to long-term averages, community wellbeing has risen to a recent high point.

Qualitative data from our interviews show:

- there have been events since the Hazelwood mine fire that have impacted community wellbeing, both positively and negatively;
- there is fatigue in the community from repeated adverse events, but also some increasing resilience;
- community wellbeing in the Latrobe Valley is variable: some groups are doing well, but there are also pockets of severe disadvantage;
- the COVID-19 pandemic and the transition away from carbon along with social issues arising from socioeconomic disadvantage and intergenerational trauma are major factors currently impacting community wellbeing;
- there are mixed views on whether community wellbeing in Latrobe Valley will improve in the future; however, most of our interviewees were cautiously optimistic.

Improvements in wellbeing will depend on a number of factors, including:

- bringing together disparate groups within the community;
- overcoming intergenerational trauma and disadvantage, the impacts of the COVID-19 pandemic and the fatigue associated with repeated adverse events;
- forging a new identity for the Latrobe Valley as it transitions away from coal;
- listening to local voices to generate local solutions to local problems;
- creating a vibrant economic future by attracting new employment opportunities, but not at the expense of the environment or the health of the community;
- improving service provision through collaboration and investment in human capital;
- addressing inequality and unequal access to the resources that promote community wellbeing (health, the economy, the environment, services and infrastructure, social connections).

5.10 Suitable comparator populations

Comparing outcomes between Morwell and Sale

CSIRO's Victoria-wide $PM_{2.5}$ model indicated that Morwell experienced the highest mine fire-related air pollution concentrations whilst Sale experienced little to none. Furthermore, the researchers were able to identify 16 Statistical Areas Level 1 (SA1s) in Sale with comparable median age, household size, socioeconomic index and population stability to Morwell. By limiting Adult Survey recruitment in Sale to these SA1s, this comparator population was as similar to Morwell as practically possible, with the exception of Hazelwood mine fire exposure.

Comparing outcomes across a gradient of $PM_{2.5}$ exposure levels

Sizeable variability in $PM_{2.5}$ exposure levels experienced by residents within Morwell and across the Latrobe Valley meant that many Hazelwood Health Study streams have been able to compare less exposed participants with more exposed participants along a gradient of exposure. This has included no exposure versus low, medium or high exposure categories, or change in health outcomes per increment in mean or peak $PM_{2.5}$ exposure for people residing across the Latrobe Valley. The ELF Study also included an unexposed comparator group by including children who were conceived after the mine fire smoke had dissipated.

Comparing outcomes across school locations, school types and grade levels

In the Schools Study, government and non-government schools across the Latrobe Valley, primary and secondary schools, and students in academic grades 3, 5, 7 and 9 each effectively became comparator groups for each other.

Comparing health outcomes over time and across Victoria

Time series analyses have been used by several Hazelwood Health Study streams to investigate trends in health outcomes observed before the mine fire, compared with trends in the same health outcomes observed after the mine fire. In effect, the pre-mine fire population became the comparator group for itself post-mine fire. Many of these analyses have compared trends in Morwell with trends in the wider Latrobe Valley, select areas of Gippsland or even all of regional Victoria.

The Hazelwood mine fire, February 2014
Photo courtesy of Keith Pakenham, CFA Victoria

6 Community engagement and dissemination of findings

Engagement with the community and key stakeholders has been an essential component of the Study's success. Strategies ensuring the Study's connection with the Gippsland community have included: key roles for Gippsland-based Monash Rural Health and Federation University, the establishment of a local Study site at the Latrobe Regional Hospital, employment of local personnel, the establishment of locally-drawn community and clinical advisory committees, attendance at local community events and presentations to community groups. Advertised annual community briefings, which were a contractual requirement, also fostered two-way communication between researchers, community members and key stakeholders.

Led by the Hazelwood Health Study Recruitment and Community Engagement Coordinator, a comprehensive marketing campaign was implemented to ensure that the Study had high visibility in the region, the community felt informed about the Study's activities and recruitment into the Study's various research streams was maximised. A key messages document was workshopped and used as the basis for radio and print advertising, promotional fridge magnets, flyers and posters. Key Hazelwood Health Study personnel attended numerous community events, community group meetings and activity hubs, such as markets, sports and social clubs, shopping centres and libraries. Free catered events were offered to the public and information packs were delivered to public venues.

The effective translation, packaging and dissemination of Study findings to diverse audiences has remained a priority for the researchers. Technical reports, manuscripts and conference presentations have been prepared for local, national and international scientific and medical audiences. Additional presentations have been prepared for emergency management and planning organisations. Lay language Research Summaries (see Volume 3 Appendix 4), videos, exhibits, e-newsletters, summary flyers (e.g., see Volume 3 Appendix 5) and media releases have been prepared in an endeavour to make the findings as accessible as possible for lay audiences.

Research Summaries on display

Professor Michael Abramson addressing the media

7 The influence of the Study on policy and practice

An ongoing focus for the Hazelwood Health Study has been to ensure that its findings meaningfully influence policy and practice. As a result of the Study's efforts, its findings have informed smoke and air pollution health guidelines from peak bodies such as the Royal Australian and New Zealand College of Obstetricians and Gynaecologists, the Environmental Health Standing Committee of the Australian Health Protection Principal Committee and the Thoracic Society of Australia and New Zealand. The Study has also directly informed the public health response to more recent fire events, including relocation advice given to smoke effected communities (e.g., the 2018 Cobrico and 2019-2020 Port Macquarie peat fires, and widespread Tasmanian fires in early 2019), and air purifiers being provided at shelters.

Study Investigators have also been called to inquiries following the Hazelwood mine fire (including legal proceedings involving the mine operators) and the 2019-2020 Black Summer fires. In addition, the Study has influenced the way the Victorian Government communicates with community members regarding smoke events, including informing the development of a smoke alert rating scale and the inclusion of smoke alerts on the VicEmergency app.

Importantly, the Study has resulted in a number of local outcomes, including the increased provision of mental health services for young people in the Latrobe Valley. Study findings have also directly informed the activities of the Latrobe Health Assembly, such as public health awareness campaigns relating to asthma management, smoking cessation and healthy eating. Further, the Study has provided the opportunity for local community members and organisations to present their vision for Morwell and the wider region through a photographic exhibition which has been presented both locally and state-wide.

8 Acknowledgements

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There are many organisations, data custodians and individual contributors to this Study who are listed in Volume 1 and who we thank for their contributions. We also acknowledge many others who have played an important part, including the local media and the organisations and businesses which have provided services and assistance in numerous ways over the Study's first ten years.