Hazelwood Health Study

9th Annual Report

16 November 2023

Contents

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Document History

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1.0	16 November 2023	Senior Project Manager	Submitted to Dept Health
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Abbreviations

ANZSRS	Australian and New Zealand Society of Respiratory Science
ATS	American Thoracic Society
COVID-19	Coronavirus Disease 2019
CVDL	Centre for Victorian Data Linkage
CWI	Community Wellbeing Index
DH	Victorian Government Department of Health
ED	Hospital Emergency Department
ELF	Latrobe Early Life Follow Up Study
ERS	European Respiratory Society
FeNO	Fraction of exhaled nitric oxide (a marker of airway inflammation)
GP	General Practitioner
GPHN	Gippsland Primary Health Network
GREMP	Gippsland Regional Emergency Management Plan
HHS	Hazelwood Health Study
HREC	Human Research Ethics Committee
LHA	Latrobe Health Assembly
MBS	Medicare Benefits Schedule
MBW	Multi-Breath Washout
MEMPC	Municipal Emergency Management Planning Committee
NAPLAN	National Assessment Program – Literacy and Numeracy
PBS	Pharmaceutical Benefits Scheme
$PM_{2.5}$	Particulate matter with a median aerodynamic diameter of 2.5 thousandths of a millimetre or less
PMG	Project Management Group
PSC	Project Steering Committee
TSANZ	Thoracic Society of Australia and New Zealand

1 Executive Summary

This is the ninth Annual Report to be submitted to the Department of Health (DH) and the Hazelwood Health Study's (HHS) 38th contractual milestone. This report provides a summary of progress made since the eighth Annual Report in November 2022.

In the last 12 months, the Project Management Group (PMG) has hosted the annual stream coordination retreat, the Annual Community Briefing, formal meetings of the Project Steering Committee, the Scientific Reference Group and regular finance committee meetings. The PMG has attended and presented at relevant meetings hosted by the DH Contract Committee, Gippsland Primary Health Network and Latrobe Health Assembly. A focus has been to investigate ways in which it can ensure that HHS findings influence meaningful change in health service provision and emergency response planning. This has included presentations to Gippsland-based emergency management groups. The PMG continues to review and track all Study outputs from conception to publication, including maintaining the Study Outputs Directory and Citations Master List (Appendices 1 and 2).

After 9 years as Principal Investigator of the HHS, Prof Michael Abramson will retire at the end of 2023. Fortunately, he will remain involved in the study. Stepping into the Principal Investigator-role, alongside co-Principal Investigator-Gippsland Dr Matthew Carroll, we welcome Prof Karen Walker-Bone, head of the Monash Centre for Occupational & Environmental Health (MonCOEH).

In the first half of year 9, the Latrobe Early Life Follow-Up (ELF) Study concentrated on analyses of previously collected clinical data, as well as identified and anonymous health services use data. Based on those data, two abstracts have been presented at conferences and two papers published in peer-reviewed journals. Four further scientific manuscripts have been progressed in relation to exposure to mine fire-related fine particulate matter with a diameter of 2.5 thousandths of a millimetre or less ($PM_{2.5}$) and lung function, vascular function, primary and pharmaceutical care and allergic sensitisation. Emergency department, hospital admission, health service and pharmaceutical data have been received from a second round of linkages with Centre for Victorian Data Linkage (CVDL), Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS). Data from the Australian Early Development Census are pending. After considerable preparation, the ELF Study's third round of clinical assessments commenced in September 2023. Recruitment closed at the end of October with 174 participants.

ELF Study participant

The Schools Study arm of the Psychological Impacts Stream has published analysis of 10 years of deidentified region-wide NAPLAN results. The adult arm of the Stream has also progressed a number of analyses from the previous 2019-2020 Mental Health and Wellbeing Follow-Up Survey. This has included publication of research papers exploring trajectories of post-traumatic stress, and the relationship between post-traumatic stress and somatic symptoms. In order to continue investigating the longitudinal course of the psychological health and wellbeing of adults in the community, the Stream conducted a second Mental Health and Wellbeing Follow-Up survey which closed in December 2022 with a 73% response rate. A technical report is nearing completion.

The Psychological Impacts and Community Wellbeing Streams have finalised collaborative work investigating associations between smoke exposure, psychological distress, socioeconomic circumstances and subsequent perceptions of community wellbeing. The Psychological Impacts and ELF Streams are continuing to collaborate on a study of parental mental health, family function and associations with the mental health and development of children. The analysis is near completion and a technical report underway.

The Impact on Community Wellbeing Stream has completed the design of a Community Wellbeing Barometer covering five key domains: health, the economy, environment, services and infrastructure, and social connection, with associated themes and objective measures. Quantitative data on these measures have been collected and the results have been discussed with a focus group of key stakeholders in the Latrobe Valley. This input has been used to revise the measures included in the Barometer and fresh calculations have been carried out. Ethics approval was received to conduct a second round of interviews. Those have been completed and are being analysed. The interviews, along with media and social media data, will contribute to assessment of subjective aspects of community wellbeing. One journal article (jointly prepared with the Psychological Impacts stream) is under review, another is being revised and a third has been published.

The Adult Survey continues to contribute valuable baseline data to the ongoing research of the Psychological Impacts, Respiratory, Cardiovascular and Hazelinks Streams. A follow-up survey was undertaken in late 2022 to investigate the association between mine fire-related $PM_{2.5}$ exposure, respiratory symptoms eight years later, smoke from the 2019/2020 “Black Summer” bushfires, COVID-19 and dietary quality. Analysis has been completed in relation to the association between $PM_{2.5}$ exposure in adults and the risk of COVID-19 infection. A poster was presented at the European Respiratory Society (ERS) 2023 International Congress and a manuscript has been published by *Respirology*. Analysis of longitudinal respiratory symptoms has been completed and a manuscript has been submitted for publication. Analysis of dietary data, along with write-up of a manuscript, has been completed and submitted to DH for review. A medical student has completed a systematic review of scientific literature exploring the association between $PM_{2.5}$, risk of

COVID-19 infection, severity of illness and mortality. The findings have been published by *Science of The Total Environment* and presented as a poster at the 2023 ANZ Society of Respiratory Science / Thoracic Society of Australia & New Zealand (ANZSRS/TSANZ) conference.

The Respiratory Stream has completed analyses and write up of Multi-Breath Washout (MBW) data from round 1 clinical assessments with findings presented at the 2023 Annual Scientific Meetings of TSANZ and ANZSRS. A corresponding manuscript is under review with *Respirology*. Analysis of the lung function data from round 2 has also been completed, with a poster presented at the American Thoracic Society (ATS) 2023 International Conference. An associated manuscript is awaiting DH approval for release. A brief manuscript describing the measurement of fractional exhaled nitric oxide (FeNO); an indicator of inflammation in the airways, is under review with a journal. After considerable planning and resourcing, the Stream's third round of clinical assessments commenced in June and concluded in October 2023 with 316 participants attending.

The Hazelinks team have progressed analyses of deidentified ambulance, hospital and cancer data extracts which included an additional 5-6 years of data since previous extractions. Meetings with Ambulance Victoria (AV) took place to clarify changes to their reporting format, so that longitudinal analysis of these data could proceed. Hazelinks has also received a further 5 years of identified data from AV, the Victorian Cancer Registry and CVDL. Linked data from the National Death Index has been received for the first time. Auditing, cleaning and analyses of these data sets are underway. A paper based on the previously received linked emergency department data has been published.

The Cardiovascular Stream is investigating the association between $PM_{2.5}$ exposure measured in the Adult Survey, cardiovascular biomarkers measured in the previous Cardiovascular Stream clinic, dietary data collected as part of both the Cardiovascular Stream and the 2022 long-term respiratory health follow-up survey and major adverse cardiovascular events (MACE) included in the identified CVDL data.

A number of strategies have been employed to maximise community engagement. Findings have been disseminated via scientific journals, conferences, the media and the HHS website. The Study has released seven lay language Research Summaries (Appendix 3). In June 2023 an e-newsletter was distributed to more than 2,100 subscribers. The Project Management Group also worked with creative agency Wellmark to produce a flyer describing several years of HHS findings (Appendix 4). The flyer was distributed to the community on 28 June 2023 as an insert to the Latrobe Valley Express newspaper. The Study's 9th Annual Community Briefing was presented by Zoom in September 2023.

2 Introduction

This is the ninth Annual Report to be submitted to the Department of Health (DH) as part of the milestones for the Hazelwood Health Study (HHS). Previously completed milestones are shown in section 3. This report comprises an overview of all HHS activities in the 12 months since the eighth Annual Report was submitted in November 2022. Copies of all previous Annual Reports can be found at www.hazelwoodhealthstudy.org.au/study-findings/study-reports/.

The HHS is overseen by a number of governing bodies which are described in section 4. Their common goals are to ensure the Study's integrity, adherence to best research practice and connections with mine fire-impacted communities, key stakeholders and important scientific audiences.

The HHS comprises a number of related research Streams with their own aims, participants and methods. Combined, the research Streams bring together participant-reported health and wellbeing information, administrative health data, educational assessments, clinical measurements and media-derived information. Participants include infants, school-aged children, adults including pregnant women and the elderly, community groups, the media and both Government and non-Government authorities. These activities aim to provide a comprehensive overview of the long-term health and wellbeing impacts of the 2014 Hazelwood mine fire upon the Latrobe Valley community. The recent activities of each Stream are presented in more detail in section 6.

Effective dissemination of findings and community engagement have been high priorities for the HHS throughout its tenure. These activities are outlined in section 7 and demonstrated further in the Appendices.

The Hazelwood Health Study website (pictured) can be accessed at www.hazelwoodhealthstudy.org.au

3 Previously completed contract milestones

Since commencement of the HHS in November 2014, and prior to the submission of this 9th Annual Report, 37 contractual milestones have been completed. Those milestones are presented in Table 1 with their delivery dates.

Table 1 Contractual milestones completed prior to this 9th Annual Report

	Contractual milestone	**Delivered**
1	Project plan	17 December 2014
2	Community and stakeholder engagement strategy	17 December 2014
3	Organisational agreements with sub-contractors	9 February 2015
4	Research ethics submission	9 February 2015
5	Advisory groups established	10 March 2015
6	Outline of Ageing Policy Review	8 May 2015
7	1st Interim Report	15 June 2015
8	1st Annual Community Briefing	11 August 2015
9	1st Annual Report	13 November 2015
10	1st Recruitment Report	15 March 2016
11	2nd Interim report	15 June 2016
12	Ageing Population Policy review	30 November 2016
13	2nd Annual Community Briefings	29 November 2016
14	2nd Annual Report	15 November 2016
15	2nd Recruitment Report	19 March 2017
16	3rd Interim report	15 June 2017
17	Contract review & revised project plan	17 July 2017
18	3rd Annual Community Briefings	9 Oct 2017 Morwell & 10 Oct 2017 Sale
19	3rd Annual Report	16 November 2017
20	4th Interim Report	22 June 2018
21	4th Annual Community Briefing	22 August 2018
22	4th Annual Report	16 November 2018
23	5th Interim Report	21 June 2019
24	5th Annual Community Briefing	11 June 2019
25	Contract review & revised project plan	17 July 2019
26	5th Annual Report	15 November 2019
27	6th Interim Report	19 June 2020
28	6th Annual Community Briefing	10 November 2020

	Contractual milestone	Delivered
29	6th Annual Report	20 November 2020
30	7th Interim Report	16 June 2021
31	7th Annual Community Briefing	11 November 2021
32	7th Annual Report	19 November 2021
33	8th Interim Report	18 May 2022
34	8th Annual Community Briefing	18 October 2022
35	8th Annual Report	18 November 2022
36	9th Interim Report	18 May 2023
37	9th Annual Community Briefing	28 September 2023

4 Project Governance

4.1 Project Management Group

The Project Management Group (PMG) continues to provide oversight to the operationalisation of the Project Plan, reviewing study progress, managing staff appointments, monitoring the budget, ensuring adherence to good research practice standards and the successful delivery of contractual milestones.

The PMG has hosted the Study's 9th annual stream coordination retreat and Community Briefing, and has coordinated and participated in all formal meetings of the Project Steering Committee, Scientific Reference Group and the finance committee. The PMG has also attended relevant meetings hosted by the Department of Health Contract Committee, Gippsland Primary Health Network and the Latrobe Health Assembly.

A sustained focus for the PMG has been to investigate ways in which it can ensure that Hazelwood Health Study findings influence meaningful change in health service provision for the mine fire affected community and emergency response planning for communities impacted by similar events in the future. The PMG and relevant Stream Leads met with the Manager, Latrobe Municipal Emergency Management, and have made a presentation to the Gippsland Municipal Emergency Management Planning Committee (MEMPC). The PMG is brainstorming other options with the Latrobe Health Assembly and the DH Contract review Committee.

The PMG has reviewed preliminary and final drafts of all reports, papers, abstracts, Research Summaries and media releases arising from HHS research, and facilitated their submission to the DH for approval. All study outputs are tracked by the PMG, from conception to publication, with updates regularly made to the Hazelwood Health Study

Outputs Directory which lists all publicly available HHS findings (Appendix 1) and the Citations Master List (Appendix 2).

The HHS budget is monitored on a monthly basis by the PMG, with planned expenditure adjusted as needed. In consultation with our Finance Business Partner, compendiums of documentation have been compiled to accompany the reimbursable expenses claims for year 8 and year 9.

The PMG has finalised an agreement with DH in regard to the long-term custodianship of the "Our Hopes for the Future of Morwell" photographic exhibition which includes some Intellectual Property arising from the Study.

With regret we announce that, after 34 years with Monash University including nine as Principal Investigator of the HHS, Professor Michael Abramson will be retiring in December 2023. Very fortunately he will remain involved in the Study. However, the Principal Investigator role will be transferred to Professor Karen Walker-Bone alongside Dr Matthew Carroll who remains co-Principal Investigator-Gippsland. Karen is Professor of Occupational Rheumatology and Director of the Monash Centre for Occupational Health (MonCOEH). Originally trained in Medicine at Southampton University Medical School, UK, Karen specialised in rheumatology and developed a particular interest in the relationship between work and health. Between 2013-2021, she was Leader of a Medical Research Council (MRC) Programme on Work and Health and Director of the MRC Versus Arthritis Centre for Musculoskeletal Health and Work. Karen joined Monash University in 2022 and is now warmly welcomed by the whole HHS team.

Professor Karen Walker-Bone

4.2 Gippsland Primary Health Network

The HHS is a standing item on the meeting agenda for the Latrobe Baw Baw Subregional Clinical Council of the Gippsland Primary Health Network (GPHN). The group meets three times a year, followed by a joint meeting with the two other Subregional Clinical Councils. This provides a regular opportunity for the Study to brief members on HHS findings and seek input on clinical matters.

In the February 2023 meeting, the Early Life Follow-up Stream presented a summary of recent findings in relation to:

- GP visits and medications prescribed to infants following mine fire exposure.
- Emergency Department (ED) visits and hospital admissions following infant exposure to mine fire smoke.

- Lung function in children at 3+ and 7+ years after mine fire exposure.

For the June 2023 meeting, the HHS provided the committee with a copy of the Executive Summary to the 8th Annual Report, along with findings in relation to:

- Long-term effects of extreme smoke exposure on vulnerability to COVID-19.
- $PM_{2.5}$ and COVID-19 infection, severity, and mortality.
- Impaired gas mixing in the lungs following coal-mine fire smoke exposure.

The next meeting is scheduled for later in November 2023.

4.3 Latrobe Health Assembly

The Latrobe Health Assembly (LHA) HHS subcommittee met several times in the last 12 months. In December 2022 the researchers updated the subcommittee in regard to progress on the Parents and Families Survey, Long-term Respiratory Survey and the Mental Health and Wellbeing Follow-up. Findings in relation to a systematic review of literature on fine particulate matter exposure and COVID-19 were described, along with ELF Study infant $PM_{2.5}$ exposure and ED presentations, and adult $PM_{2.5}$ exposure and lung function. potential for building the Study findings into current organisational emergency management plans was discussed.

As a result of the December 2022 discussions, a special meeting took place on 15 February 2023 with John Crane, then Manager, Latrobe Municipal Emergency Management, Chair of the Municipal Emergency Management Planning (MEMP) Committee. It was noted that the local MEMP was updated in 2022 so was not due for full review for three years. However, a staged quality review was underway, with one third of the document reviewed each year. This raised the opportunity for HHS findings to inform the ongoing development of the MEMP. It was noted that there was an absence of a resilience/recovery component to the plan and that HHS findings could help close this gap. It was agreed the Manager would be invited to attend the June LHA HHS sub-committee meeting. It was noted that representatives from HHS and LHA were available and keen to present to the MEMP Committee meeting upon invitation.

Following the February meeting to discuss the Latrobe City MEMP, a zoom discussion was held with two key Department of Health contacts to discuss the process for informing the wider Gippsland Regional Emergency Management Plan (GREMP), which was due for review in October 2023. Ellen Brown, Regional Manager- Emergency Management for the Southern Victorian Region, and Kenton Winsley, Regional Director Public Health & Emergency Management, were provided with an overview of study findings relevant to region-wide emergency planning. They noted the clear potential for Hazelwood findings to

inform planning for the region and wider Victoria, including the possibility of inviting the team to present to the Gippsland Regional Emergency Management Planning Committee.

The LHA subcommittee met again in early March 2023. The Executive Summary to the 8th Annual Report was presented, as were preliminary findings in relation to Adult Survey $PM_{2.5}$ exposure and COVID-19 infection, and the association between early life $PM_{2.5}$ exposure, GP visits and prescribed medications. Key LHA members subsequently participated in the 2023 stream coordination retreat.

Justin Murray, who replaced John Crane as the Acting Manager – Emergency Management, Latrobe City Council, was introduced to the sub-committee at its June 2023 meeting. Mr Murray was provided an overview of the HHS program. The potential for HHS findings to inform planning for future events, at the local, regional and state level, was discussed. It was noted that HHS findings could inform dialogue about at-risk community members, evacuation strategies, emergency response management and communication with impacted communities. There was discussion around communication strategies to connect with impacted communities, such as planned burns, and informing at-risk community members. It was noted that community strategies involve emergency response agencies, such as Victoria Police and Forest Fire Management Victoria.

Mr Murray acknowledged the importance of relief and recovery planning and the possibility of building the HHS findings in early to inform when and how warnings might be released, appropriate language use etc. It was noted that there may be an opportunity for the HHS/LHA to attend the next Municipal Emergency Management Planning Committee (MEMPC) meeting scheduled for September.

At the September 2023 meeting the group continued discussions regarding the HHS findings informing emergency management. Recently released ELF Study findings in regard to the assessment of allergies in smoke exposed children were presented. Sub-committee members, along with Marita Dalton from the ELF Stream and Sue Yell from the Community Wellbeing Stream, then participated in the September meeting of the MEMPC, which generated considerable interest from the emergency management stakeholders including members from Ambulance Victoria, Country Fire Authority and Victoria Police.

The next LHA HHS subcommittee meeting is scheduled for 4 December 2023.

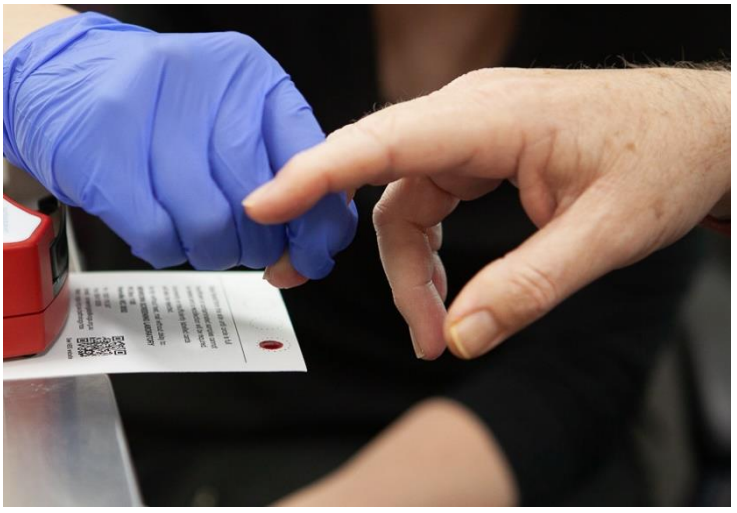
4.4 Project Steering Committee

The Project Steering Committee (PSC) provides overall strategic guidance for the HHS. PSC membership comprises each of the Stream leads and the Project Management Group members. During the last 12 months there have been four formal meeting of the PSC plus out-of-session consultations. All Stream Leads presented progress updates and future

plans for their streams at the annual stream coordination retreat and the Annual Community Briefing.

4.5 Scientific Reference Group

The Scientific Reference Group (SRG) met in July 2023. The Group reviewed the Executive Summary from the 9th Interim Report, the HHS Outputs Directory (Appendix 1), an overview of recent findings, the Research Summaries (Appendix 3) released since the previous meeting and the recent community flyer (Appendix 4). The Group considered the works in progress and the Study's future plans.



Testing in the 2023 Respiratory Stream clinic

5 Stream coordination retreats

The Study's ninth annual stream coordination retreat was held on 22 March 2023. Participants joined by individual Zoom link or in small groups at three locations; Monash University School of Public Health and Preventive Medicine (SPHPM), Monash Rural Health (MRH) and University of Tasmania's Menzies Institute for Medical Research. The retreat involved members of all HHS research streams, project staff and students. Guest participants included Jane Anderson (Latrobe Health Advocate), Ellen-Jane Browne (Latrobe Health Assembly), Taylin Gourley (Latrobe City Council), Alyce Wilson and Nadine Frescura (Gippsland Region Public Health Unit) and Liz Craig (GPHN).

All Streams presented a review of findings to date, outputs (e.g. Figure 1), current status and their 2023 study plan. Other discussion areas were:

- Beyond year 10: the future of the HHS.
- Appropriate forums for disseminating findings to influence policy and practice.
- Connecting the study to the community via the LHA and other organisations.

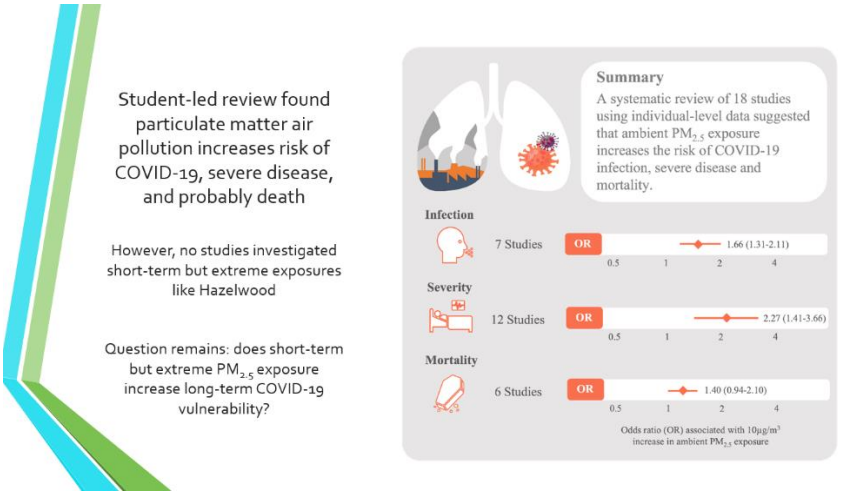


Figure 1. Example slide from the Adult Survey Stream's presentation to the Annual Retreat

An additional brainstorming session took place on 20 July 2023 to consider the potential for future Hazelwood Health Study research, including the proposed years 11-20 research program. The session was supported by the SPHPM Executive, with Prof Sally Green (SPHPM Deputy Head of School [Research]) facilitating the discussion, Prof Helen Skouteris (SPHPM Head of the Health and Social Care Unit) providing insights into potential research directions, and Dr Tsharni Zazryn and Jennifer Steen providing advice on research management matters. It was clear from the discussion that there is strong interest in continuing the Hazelwood program. A follow-up discussion, including local input from Jane Anderson (Latrobe Health Advocate) and Ellen-Jane Browne (Latrobe Health Assembly) is being planned for late November.

6 Research updates

6.1 The Latrobe Early Life Follow-up (ELF) Study

6.1.1 Publications

In the last 12 months, the ELF Study has completed numerous analyses of previously collected data. These have been the focus of two abstracts submitted to national and international conferences and six scientific manuscripts.

Abstracts

- Hemstock EJ, Foong R, Hall G et al (2023) "Health impacts of exposure to air pollution in early childhood." Presented to The Australia & New Zealand Society of Respiratory Science and The Thoracic Society of Australia and New Zealand (ANZSRS/TSANZ) Annual Scientific Meeting, Christchurch, NZ 25–28 March 2023. (Finalist in the TSANZ New Investigator Award).
- Ziou M, et al (2023) “Allergic sensitisation following early life exposure to the Hazelwood mine fire.” Presented to the Australian Public Health Conference, 26-28 September 2023.

Manuscripts

- Hemstock EJ, Foong RE, Hall GL et al (2023) “No association between *in utero* exposure to emissions from a coalmine fire and post-natal lung function.” Published in April 2023 by *BMC Pulmonary Medicine* and freely available at https://bmcpulmmed.biomedcentral.com/articles/10.1186/s12890-023-02414-7. A lay language Research Summary was previously placed on the HHS website in July 2022.
- Ziou M, et al (2023) “Contrasting health outcomes following a severe smoke episode and ambient air pollution in early life: Findings from an Australian data linkage cohort study of hospital utilisation.” Published by *Environmental Health Perspectives* and available at https://ehp.niehs.nih.gov/doi/10.1289/EHP12238. A lay language Research Summary was previously placed on the HHS website in November 2022.
- Ziou M, Gao CX, Wheeler AJ et al (2023) "Primary and pharmaceutical care usage concurrent associations with a severe smoke episode and low ambient air pollution in early life” published in July 2023 by *Science of the Total Environment*. https://www.sciencedirect.com/science/article/pii/S004896972302199X. A lay language Research Summary was placed on the HHS website in January 2023.

- Ziou M, Gao CX, Wheeler AJ et al (2023) “Exposure to air pollution concentrations of various intensities in early life and allergic sensitisation later in childhood.” Under review with *BMC Pulmonary Medicine*. A lay language Research Summary was placed on the HHS website in July 2023.
- Hemstock EJ, Foong RE, Hall GL et al (2023) “Lung function changes in children exposed to mine fire smoke in infancy” in final stages of review with *Respirology*. A lay language Research Summary was placed on the HHS website in May 2023.
- Hemstock EJ, Bigaran A, Allgood S et al (2023) “Increased vascular stiffness in children exposed *in utero* but not children exposed postnatally to emissions from a coalmine fire” in preparation for submission to a journal.

6.1.2 Assessment of parental mental health and family function

As discussed further in section 6.2, the ELF Study has joined forces with the Psychological Impacts Stream to survey ELF Study families to investigate the association between parental mental health and family functioning.

6.1.3 Data linkage

Identified extracts from the Center for Victorian Dala Linkage (CVDL) containing hospital admission and ED attendance data for the period 1/1/2018 – 31/12/2021 have been received and are being analysed. Identified extracts containing MBS/PBS usage data for the period 1/1/2017 – 31/12/2021 have also been received and these too are being analysed. Similar extracts for the anonymised (Victoria-wide) cohort have been received and are being reviewed. A first release of both anonymised and identified cohort data from the Australian Early Development Census.

6.1.4 Round 3 clinical assessments

After considerable planning and resourcing, the ELF Study’s third round of clinical assessments commenced in September and concluded at the end of October 2023 with 174 participants. This round enables the Stream to conduct longitudinal analyses of respiratory health in young children at three time points after the mine fire. The clinical assessments included spirometry (a routine lung function test) for the first time because some of the children were then old enough for reliable measurements.

Round 3 spirometric assessment

6.2 Psychological Impacts

6.2.1 Schools Study

In the last 12 months, the *Schools Study* has published two manuscripts.

- Gao CX, Broder JC, Brilleman S et al. (2022) “Evaluating the impact of Hazelwood mine fire event on students’ educational development with Bayesian interrupted time-series hierarchical meta-regression.” This manuscript, utilising 10 years of NAPLAN data, was published in March 2023 by the journal *PLoS ONE* and is freely available at https://doi.org/10.1371/journal.pone.0281655. The associated Research Summary is on the HHS website.
- Maybery D, Berger E, Dipnall J et al. (2022). “Posttraumatic stress among school-aged students following a mine fire.” This manuscript was published in June 2023 by the *Journal of Aggression, Maltreatment and Trauma* and is available at www.tandfonline.com/doi/abs/10.1080/10926771.2023.2228240. The associated Research Summary is on the HHS website.

6.2.2 Adult psychological health and wellbeing

A further two manuscripts based on adult psychological health research have been published.

- Gao CX, Menssink J, Campbell TCH et al. (2022). “Somatic symptoms, psychological distress and trauma in response to climate disasters: Lessons from 2014 Hazelwood mine fire and 2019-20 Black Summer bushfires in Australia.” This manuscript was published by *BMC Public Health* in August 2023 and is freely available at https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-16501-1. The associated Research Summary is on the HHS website.

- Smith CL, Campbell TCH, Gao CX et al. (2023) “Sociodemographic circumstances, health, and life experience shape posttraumatic distress trajectories among individuals exposed to smoke during a large-scale coal mine fire” (previously titled “Trajectories of posttraumatic distress after smoke exposure during a coalmine fire: An analysis of risk and protective factors”). This manuscript was published in April 2023 by the *Journal of Traumatic Stress* and can be found at www.onlinelibrary.wiley.com/doi/10.1002/jts.22923. The associated Research Summary is on the HHS website. Figure 2 demonstrates some of the main findings in this paper.

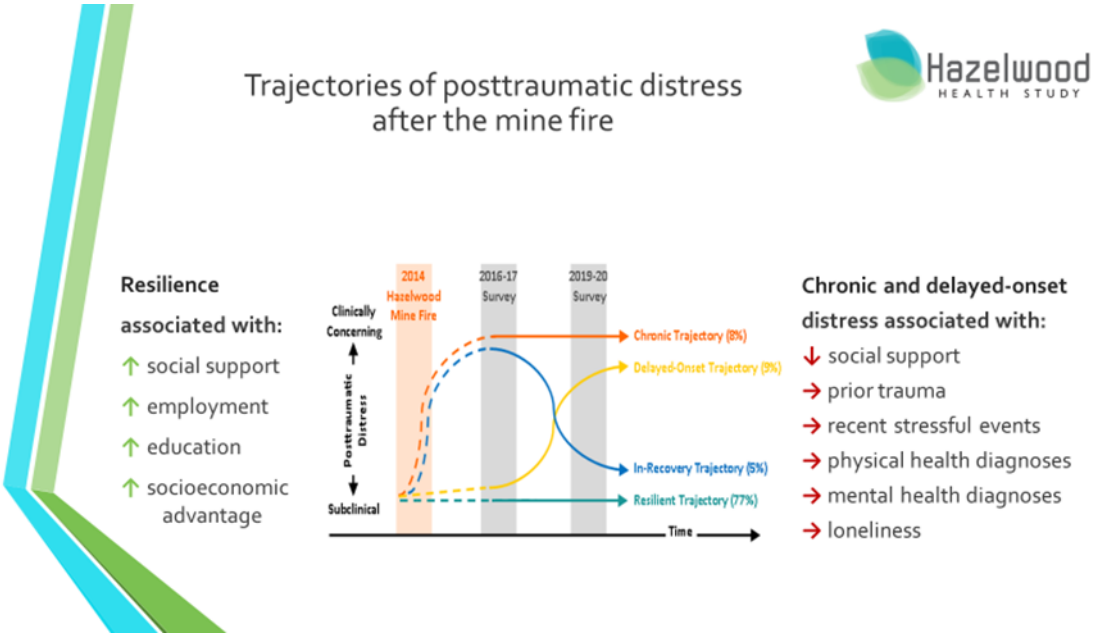
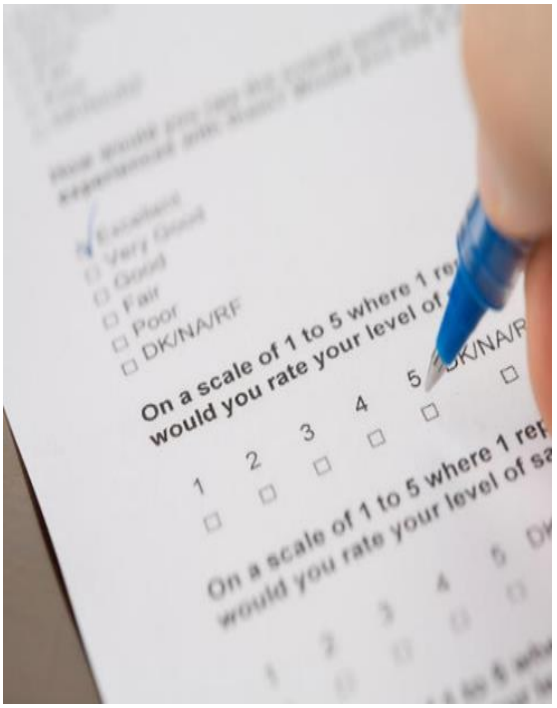


Figure 2. Associations presented in the 2023 posttraumatic distress trajectories manuscript.

2022 Mental Health and Wellbeing Follow-Up Survey.

Recruitment for the second Mental Health and Wellbeing Follow-Up to the baseline 2016/2017 Adult Survey closed in December 2022 with 524 participants from 709 invitations (74%). The latest follow-up survey included additional measures of health-related quality of life and posttraumatic growth, as well as concerns in relation to the 2019-2020 “Black Summer” bushfires and the COVID-19 pandemic. This enables the Stream to investigate longitudinal psychological health and wellbeing in the local community across three time-points after the mine fire, and in the context of more recent events. Analysis is at an advanced stage and a technical report is being prepared.



Collaboration with the Community Wellbeing Stream

In a collaboration with the Community Wellbeing Stream, the Psychological Impacts Stream is investigating the relationship between individual wellbeing and community wellbeing in Morwell using the Community Wellbeing Index (CWI). The CWI was administered as part of the 2019-2020 and 2022 Mental Health and Wellbeing Follow-Up

Surveys. Analysis of the 2019-2020 data has been completed, which investigated associations between smoke exposure, psychological distress, sociodemographic circumstances and perceptions of community wellbeing. A manuscript has been drafted for submission to a journal and is currently under review by the Department. As this was one of the first times the CWI had been used in English, the Stream is collaborating with the Spanish developers of the measure, and other international researchers, to conduct a cross-national evaluation. Approval to include deidentified HHS CWI data in this collaboration was provided by the DH in November 2020. The psychometric analysis is now underway and the research team are contributing to the reporting of methodology and results.

Another key point of collaboration with the Community Wellbeing Stream has involved the inclusion of questions relating to individual wellbeing in interviews conducted by that stream. The second round of interviews is now complete and, once the qualitative analysis is completed, the two Streams will commence work on interpreting and writing up the findings. Further detail about this research is provided in the Community Wellbeing Stream summary below.

6.2.3 Family function

In collaboration with the ELF Study, the Psychological Impacts Stream developed a survey to investigate parental mental health, family functioning and their associations with the physical and mental health and development of the children. In total, 227 parents of 249 ELF Study children participated in the survey between May and July 2022. The final dataset has been prepared and analysis is underway.

6.2.4 Student development

The Stream continues to foster capacity building and skills development by supporting students. The final qualitative paper on the service needs of young adults, from Katelyn O'Donohue's now completed PhD program exploring the impact of the Hazelwood event on younger adults, is being revised before being resubmitted to a journal. The ongoing collaboration with Dr Emily Berger from the School of Educational Psychology & Counselling in the Monash Faculty of Education continues to involve research students, with Lulu Cheng commencing her PhD candidature in July. This project will include analysis of the family functioning data from the recent survey of ELF families.

6.3 Impact on Community Wellbeing

The Impact on Community Wellbeing Stream's current research aims are to:

- continue to assess **perceptions of the community's wellbeing and recovery** after the Hazelwood mine fire, taking into consideration subsequent events (e.g., the closure of the Hazelwood power station and Morwell mine, and other large local employers, the release of HHS results) and recent initiatives (such as the Latrobe Health Innovation Zone, Latrobe Health Assembly and Latrobe Health Advocate);
- develop a **community wellbeing barometer** that brings together community perceptions of wellbeing and existing community wellbeing indicator proxy measures. The aim of the barometer is to provide a holistic tool to capture the changes in key dimensions that underpin community wellbeing;
- examine the **relationship between community wellbeing and personal wellbeing** (in conjunction with the Psychological Impacts stream).

As previously described, a first round of qualitative data collection covering all three of the above research aims was completed in 2021, with interviews taking place with 30 stakeholders and community members. Qualitative analysis of those interviews has been completed.

A second round of interviews with community members and stakeholders was undertaken in 2023. These interviews asked about perceptions of community wellbeing, and also included questions on individual wellbeing (to provide qualitative data for the Psychological Impacts Stream). Thirty interviews have been completed. While some respondents have told us that, 9 years on from the mine fire, its impacts on wellbeing are low, for others personally the impact is still significant. Preliminary analysis of the interviews shows that community wellbeing is impacted by concerns about the lack of a sense of safety on the streets, difficulty accessing GPs and allied health services, community members seeing an increase in people with apparent mental health issues in public spaces, homelessness and the longer-term future of industry. There are feelings of optimism around the transition from brown coal, but also fears about the Latrobe Valley becoming a site for future 'dirty' industries or that promised new industries will not eventuate. However, respondents have also commented on positives such as the Gippsland Pride Initiative, increased collaboration between organisations and respectful relationships between organisations and professionals. Personal connections with family, friends and neighbours are also valued and seen as strengths. Transcription of all second-round interviews is complete and a full qualitative analysis is now under way.

Figure 3. Model of the Community Wellbeing Barometer domains and themes

The Stream has developed a Community Wellbeing Barometer focusing on five domains impacting on wellbeing: health, the economy, environment, services and infrastructure, and social connection. For each domain we have identified 4-5 themes, as shown in Figure 3. Preliminary analysis of a selection of candidate measures for each of the themes was undertaken. These preliminary results were presented in two stakeholder consultations in late 2022, which included representatives from the Latrobe Health Assembly, Latrobe Health Advocate, Latrobe Valley Authority, Latrobe City and GPHN. The feedback they provided has been analysed and used to revise the Barometer, so that it incorporates the most accurate and appropriate measures and data sources to track community wellbeing in this region. Some measures have been dropped and others added to better reflect the model and to make use of available continuing data sources. A revised graph has been created which adds up the measures for all 5 domains, to present an overall picture of trends in community wellbeing (Figure 4). The barometer results will be externally validated through comparison with other composite measures. Benchmarking will also be carried out against other regions or, possibly the State as a whole.

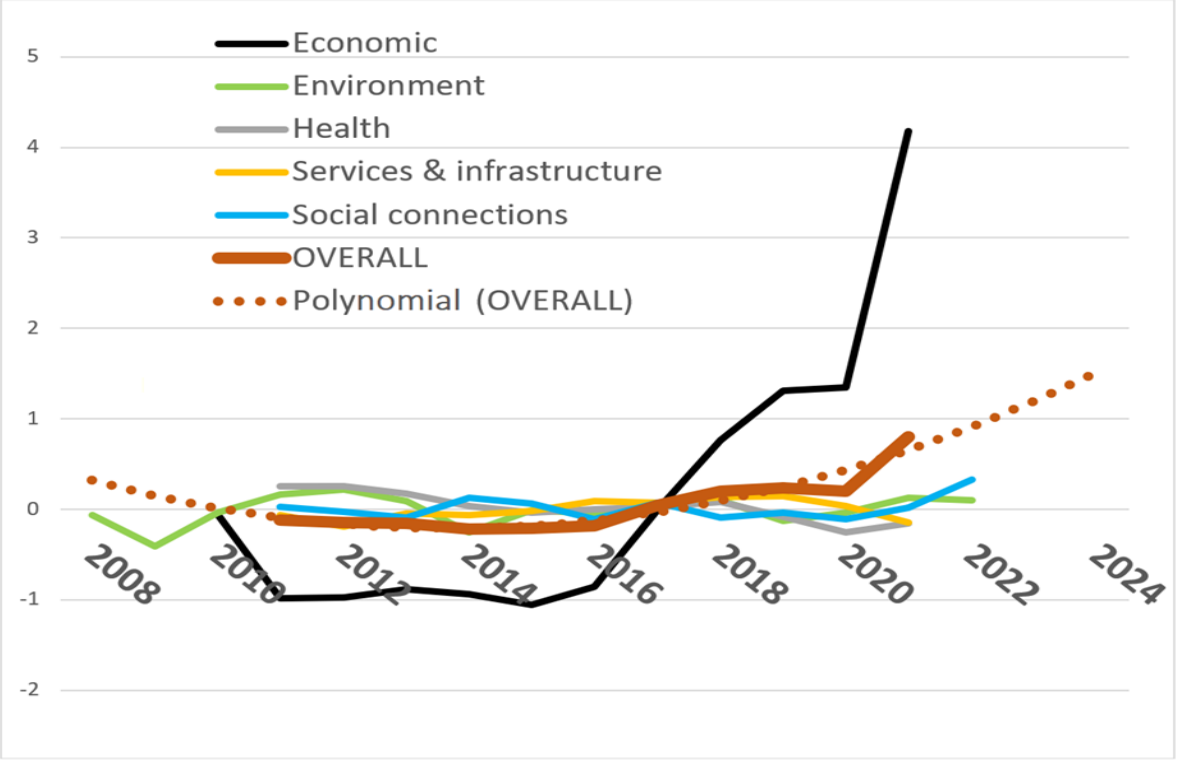


Figure 4. Barometer results: summated theme scores against each Domain and overall trend

As in Years 1-8, we continue to collect data from media and social media to contribute to analysing subjective aspects of community wellbeing. Data collection is focused around specific events since the mine fire. The identification of key events was based on interviewees' responses to a question about which events and initiatives they believed had impacted on the community's wellbeing since the mine fire. This data collection has been completed for the period 2017-2021, and those data are still being analysed.

As referred to in section 6.2, the Impact on Community Wellbeing Stream is collaborating with the Psychological Impacts Stream to look at the intersection between individual and community wellbeing using the CWI. Analysis of the CWI data has been completed, and a paper has been submitted to DH, looking at current community wellbeing and change in community wellbeing since the mine fire, taking into consideration level of exposure to the smoke event and other sociodemographic and health risk factors. As noted above, the two streams have worked together to interpret the findings, provide insights into changes to community wellbeing and the relationship between community wellbeing and individual wellbeing. This work will be further informed by the qualitative analysis of the interview data regarding the links between individual and community wellbeing.

A conference presentation delivered in 2021 has been developed into a journal article on optimal communication during complex disasters with health impacts. The article is undergoing revisions before being re-submitted to a journal. This work contains previously published findings from the Community Wellbeing Stream interviews and the previous HHS

Policy review of the impact of the Hazelwood mine fire on older people, as part of a broader discussion with additional examples, including COVID-19 crisis communication.

A conference presentation delivered at the Mobility Justice Symposium, held at the University of Wollongong in 2022, has been developed into an article for a special issue of the *Australian Geographer* on the theme of mobility justice. This article also drew on previously published findings from the Community Wellbeing stream interviews and has now been published.

Publications

- Carroll M, Campbell TCH, Smith C et al (2023) "Predictors of residents' perspectives on the wellbeing of their community in the aftermath of a prolonged coalmine fire." Recently submitted to DH for review.
- Duffy M, Yell S, Walker L et al (2023) "The social justice issues of smoke im/mobilities, *Australian Geographer*, 54:4, 573-587, DOI: 10.1080/00049182.2023.2256595.
- Yell S, Carroll M, Duffy M et al (2023) "Learning lessons in disaster communication: From the Hazelwood mine fire to the COVID-19 pandemic." In preparation for submission to a journal.

6.4 Adult Survey

Participants from the 2016/2017 Adult Survey continue to form the basis for the Mental Health and Wellbeing Follow up Surveys (see section 6.2), adult Respiratory Stream (see section 6.5), Hazelinks identified linkages (see section 6.6) and the adult Cardiovascular Stream (see section 6.7).

6.4.1 Long term respiratory health follow-up survey

As presented in the 8th Annual Report, a new follow-up survey of a sub-sample of Adult Survey participants was led by Dr Tyler Lane in 2022. Not previously included in the Hazelwood Health Study Project Plan, the specific research questions were:

1. Does $PM_{2.5}$ exposure from the Hazelwood mine fire predict poorer respiratory health eight years later?
    a. Are effects moderated by previous COVID infection, the Black Summer bushfires, or dietary quality?
2. Does $PM_{2.5}$ exposure from the Hazelwood mine fire or the Black Summer increase COVID infections and illness severity?

3. Is dietary quality associated with slower deterioration in lung function in people with high $PM_{2.5}$ exposure?



Recruitment closed in December 2022 with 612 participants. Analysis of findings in relation to the association between mine-fire related $PM_{2.5}$ exposure in adults and the odds of COVID-19 infection have been completed. A poster was accepted for presentation at the European Respiratory Society (ERS) 2023 International Congress and the Australasian Epidemiological Association (AEA) 2023 Annual Scientific Meeting.

- Lane T, Carroll M, Borg B et al (2023) "Long-term risk of COVID-19 after extreme smoke exposure." ERS 2023 International Conference, Milan, 9-13 September 2023. Available at https://erj.ersjournals.com/content/62/suppl_67/PA3810.
- Lane T, Carroll M, Borg B et al (2023) "Long-term risk of COVID-19 after extreme smoke exposure." AEA 2023 Annual Scientific Meeting, Melbourne, 18-20 October 2023.

A manuscript has also been finalised, published on the Health Sciences preprint server medR$_X$iv and also peer reviewed and published by *Respirology*. This attracted favourable editorial comment in the same issue; see https://doi.org/10.1111/resp.14622.

- Lane T, Carroll M, Borg B et al "Long-term effects of extreme smoke exposure on COVID-19: A cohort study." This manuscript was published in September 2023 by *Respirology* and is freely available at https://onlinelibrary.wiley.com/doi/10.1111/resp.14591

In further regard to the research question relating to COVID-19, Dr Lane supervised a final year medical student on a Scholarly Intensive Placement, who undertook a systematic review of scientific literature exploring the association between fine particulate matter, risk of COVID-19 infection, severity of illness and mortality. The findings have been published by *Science of The Total Environment* and presented as a poster at the 2023 ANZSRS/TSANZ conference.

- Sheppard N, Carroll M, Gao CX and Lane T (2023) "Particulate matter air pollution and COVID-19 infection, severity, and mortality: A systematic review and meta-analysis." The manuscript was published in April 2023 by *Science of The Total*

Environment and is freely available at https://www.sciencedirect.com/science/article/pii/S0048969723018910

- Lane T, Sheppard N, Carroll M and Gao C (2023) “Particulate matter air pollution and COVID-19 risk: A systematic review." Poster presented at The Australia & New Zealand Society of Respiratory Science and The Thoracic Society of Australia and New Zealand (ANZSRS/TSANZ) Annual Scientific Meeting, Christchurch, NZ, 25–28 March 2023.

Analysis of longitudinal respiratory symptoms have been completed utilising data which were self-reported in the baseline 2016-2017 Adult Survey and the 2022 Long term Respiratory Health Follow-up Survey. An abstract was accepted for presentation at the Australasian Epidemiological Association (AEA) 2023 Annual Scientific Meeting.

- Lane T., et al. (2023) “Respiratory symptoms after coalmine fire and pandemic: a longitudinal analysis of the Hazelwood Health Study adult cohort.” AEA 2023 Annual Scientific Meeting, Melbourne, 18-20 October 2023.

A manuscript has also been prepared.

- Lane T, Carroll M, Borg B et al (2023) “Respiratory symptoms after coalmine fire and pandemic: a longitudinal analysis of the Hazelwood Health Study adult cohort.” The manuscript has been submitted to a journal. A preprint was published on *medRxiv* in August 2023 and is freely available at https://www.medrxiv.org/content/10.1101/2023.08.23.23294510v1.

Some complexities around the diet quality component of the Long-term Respiratory Health Follow-up Survey meant that a number of participants did not complete, or only partially completed, the dietary questions. However, the analysis and write up of the dietary data has been completed.

- Govindaraju T, Man M, Owen A et al (2023) “Does diet quality moderate the long-term effects of discrete but extreme PM2.5 exposure on respiratory symptoms? A study of the Hazelwood coalmine fire.” Submitted to DH.

6.5 Respiratory Stream

6.5.1 Analysis of round 1 Multi-Breath nitrogen Washout data

HHS Respiratory Scientist, Thomas McCrabb, has completed investigating the impact of coal mine fire smoke on small airways using Multi-Breath nitrogen Washout (MBW) data from the Respiratory Stream’s round 1 clinical assessments. Findings were presented at the 2023 ANZSRS/TSANZ Meeting.

- McCrabb T, Borg B, Gao CX et al (2023) "Increased conductive ventilation heterogeneity following exposure to coal-mine fire smoke." Abstract presented to The Australia & New Zealand Society of Respiratory Science and The Thoracic Society of Australia and New Zealand (ANZSRS/TSANZ) Annual Scientific Meeting. Christchurch, NZ, 25–28 March 2023.

Write up of a manuscript for consideration by a scientific journal has also been completed along with a lay language Research Summary.

- McCrabb T, Borg B, Gao CX et al (2023) “Ventilation heterogeneity is increased in adults exposed to coal mine fire-related $PM_{2.5}$. Under review with *Respirology*.

6.5.2 Analysis of round 2 clinical data collection

Analysis of the lung function data has been completed and an abstract was accepted as a poster presentation at the American Thoracic Society (ATS) 2023 International Conference.

- Holt et al (2023) “Change in Lung Function After Exposure to Smoke from a Mine Fire: A Clinical Follow-up.” Presented as a poster by the ATS International Conference, Washington DC, 19-24 May 2023.

A corresponding manuscript has also been completed.

- Holt NR, Smith CL, Gao CX et al (2023) “Lung function may recover after exposure to smoke from a coal mine fire: cohort study.” This is under review with the DH.

Round 2 clinical data collection included a measure of fractional exhaled nitric oxide (FeNO) in the breath of patients. Nitric oxide is a biomarker for asthma which provides an indication of the level of inflammation in the lungs. Led by a doctoral scholar visiting from the Leibniz Research Institute for Environmental Medicine, Düsseldorf, analysis of FeNO data has been completed and a brief report has been prepared. That report was approved by the DH in September 2023 and submitted to a journal in October.

6.5.3 Round 3 clinical data collection

The first half of 2023 involved considerable planning toward the establishment of the clinic required for the 3rd round of testing. This included reviewing all testing protocols, updating HREC applications, recruiting and training staff, sourcing staff accommodation in Gippsland, clinic rental, equipment calibration and the purchasing of consumables. Participant invitation materials were sent out in late May 2023 and appointments commenced in June. Invitations were sent to all round 1 Respiratory Stream cohort members regardless of participation in round 2, excluding those who had specified no further contact or had been identified as deceased (eligible N=502). Early recruitment rates

were quieter than hoped for. In response, and to maximise the value of the investment of resources into the clinic, the researchers decided to expand recruitment to include a limited sample of 322 Adult Survey cohort members who had not previously been recruited into the 2017 Respiratory Stream cohort. Recruitment closed in October 2023. The final number recruited into the round 3 Respiratory Stream clinical testing was 316, comprising 244 (48% of 502) Respiratory Stream cohort members and 74 (23% of 322) additional Adult Survey cohort members.

6.6 Hazelinks

6.6.1 Deidentified data extractions

Previously, the HHS had obtained deidentified extractions of data from the Victorian Cancer Registry (VCR) for the period January 2009 to December 2015, Ambulance Victoria (AV) for the period January 2009 to March 2015, and the Centre for Victorian Data Linkage (CVDL; comprising hospital admissions and emergency department presentations) for the period January 2009 to June 2015. In the early months of year 9, 2nd sets of deidentified data extracts from these sources were obtained. Those included VCR data to December 2021, AV data to June 2020 and CVDL data to June 2022. Those data have been audited for completeness. There were several missing variables and incomplete records in the VCR data which required further liaison to obtain the complete data set. In the time period between the 1st and 2nd deidentified data extractions, AV upgraded their response system so that calls to 000 were triaged with some callers being referred to GPs or other services. This altered the reporting format and required further meetings with AV to clarify the variables to ensure the analysis was consistent. Analyses of the data from VCR and CVDL are complete and two scientific manuscripts are in preparation. These examine whether cancer incidence and survival among people with cancer was affected by the fire.

6.6.2 Identified data linkages

In year 9 the researchers have also obtained identified linked data from AV, the VCR, the CVDL and the National Death Index to follow the health of the Adult Survey Cohort who consented to having their data linked. These comprise a 2nd round of linkages with AV, the VCR and the CVDL; each providing approximately 5 additional years of data since previous linkages. However, this will be the first linkage with the National Death Index. Auditing, cleaning and analyses of these data sets are underway.

6.6.3 Publications

Hazelinks has progressed the following manuscripts in the last 12 months:

- Smith C, Gao CX, Xu R, et al (2023) “Long-term impact of exposure to the 2014 Hazelwood coal mine fire on emergency department presentations in Australia.” Published by the journal *Environmental Research* in April 2023 and available at www.doi.org/10.1016/j.envres.2023.115440
- Lane T, Smith C, Gao CX et al (in preparation). “Long-term effects of a coalmine fire on hospital and ambulance use: an interrupted time series study.” Draft near completion.
- Lane T, Yu P, Gao CX et al (in preparation). “Survival among cancer patients after coalmine fire: Analysis of registry data in regional Victoria, Australia.” Draft near completion.

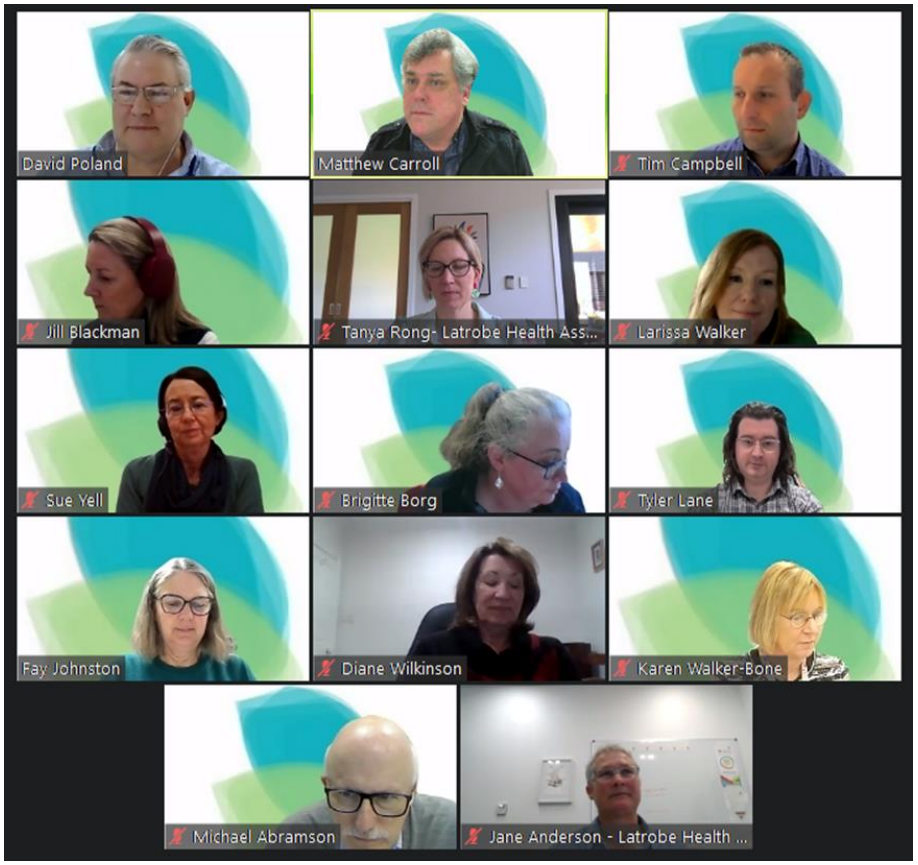
6.7 Cardiovascular Stream

Ongoing assessment of cardiovascular outcomes in the community is being achieved as part of the ELF, Hazelinks and Adult Survey Streams. For example, a recently appointed Research Fellow is investigating the association between $PM_{2.5}$ exposure measured in the Adult Survey, cardiovascular biomarkers measured in the previous Cardiovascular Stream clinic, dietary data collected as part of both the Cardiovascular Stream and the 2022 long-term respiratory health follow-up survey and major adverse cardiovascular events (MACE) included in the identified CVDL data.

7 Dissemination of findings and community engagement

The HHS employs a number of strategies in order to disseminate findings across a wide range of audiences and to maintain engagement with the local community. As described in section 7, a number of scientific journal papers have been progressed toward publication and several abstracts have been submitted for presentation at scientific conferences. A Citations Master List (see Appendix 2) is maintained by the PMG and this provides scientific audiences with the citations for all HHS scientific publications.

The Study 9th Annual Community Briefing was delivered on the 28th September by Zoom Webinar. Presenters included representatives from the PMG and each Study Stream. Additional panellists, available to address any questions from the audience relevant to their roles, included the Latrobe Health Advocate, Jane Anderson, and Latrobe Health Assembly representatives Tanya Rong and Diane Wilkinson. Live participation was modest, with approximately 30 people in the audience, including local community members as well interested people from the health sector. The presentation was recorded and a link has been provided on the HHS website.



A screen shot of a selection of the 2023 Annual Community Briefing presenters and panellists

The HHS website (www.hazelwoodhealthstudy.org.au) is regularly updated with Study Reports, Conference Proceedings and Publications. When appropriate, new findings are accompanied by a lay language Research Summary which is written with the local community audience in mind. In the last 12 months, seven lay language Research Summaries (see Appendix 3) have been added to the Fact Sheets and Summaries page of the HHS website. The Research Streams section of the HHS website is routinely revised to reflect the up-to-date status for each Stream. In an effort to further develop engagement within the community, the HHS website has been populated with additional audio-visual resources, ranging from photographs of research activities, through to edited / segmented excerpts of our Annual Community Briefing sessions being added to the relevant Stream pages and the Local Outcomes to Date page.

The HHS Outputs Directory (see Appendix 1) is maintained by the PMG. This lists all publicly available study outputs and how to access them, e.g. scientific journal papers, conference abstracts, technical reports, Research Summaries and exhibits. The Outputs Directory is regularly updated and posted to the HHS website.

An e-newsletter was disseminated to more than 2,100 subscribers in June 2023 as a further activity aimed at maintaining the Study's public profile, keeping the community updated on findings and maintaining contact with the participating cohorts. All e-newsletters are also placed on the HHS website at https://hazelwoodhealthstudy.org.au/news-and-events/e-newsletters.

The study has received some media attention, with research describing the association between $PM_{2.5}$ exposure and ED presentations published by *The Guardian.*

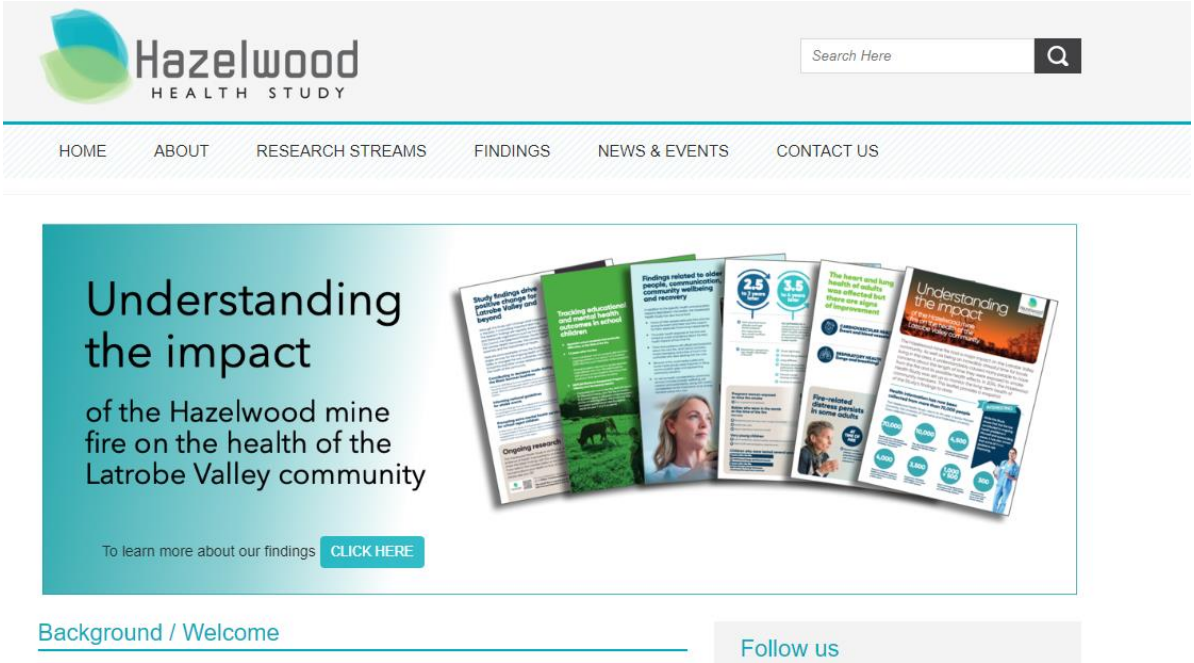

Smoke exposure from intense fires linked to long-term respiratory and cardiovascular disease

Scientists studying 2014 Hazelwood coalmine fire say breathing in tiny particles is linked to increased emergency presentations

- Follow our Australia news live blog for the latest updates
- Get our morning and afternoon news emails, free app or daily news podcast

Screenshot from *The Guardian* 15 February 2023. Source www.theguardian.com/australia-news/2023/feb/14/smoke-exposure-from-intense-fires-linked-to-long-term-respiratory-and-cardiovascular-disease? Accessed 16/05/2023.

The PMG have worked with Wellmark (www.wellmark.com.au), an advertising agency specialising in healthcare, on a campaign designed to enhance the profile of the study findings across the local community. The campaign commenced with a 6-page lay language flyer (Appendix 4), which was disseminated across the Latrobe Valley community as an insert in the Latrobe Valley Express newspaper on the 28th June 2023. The flyer summarised findings from the first several years of the Study. A 2nd flyer is proposed for 2024.



Screenshot of the Hazelwood Health Study website promoting the community flyer.

As previously described (see sections 4.1 and 4.3) the PMG have also disseminated findings by making presentations to the Manager, Latrobe Municipal Emergency Management, and to the Latrobe Municipal Emergency Management Planning Committee.

8 Appendices

Appendix 1

Appendix 2

Appendix 3

Appendix 4

Hazelwood Health Study outputs which are publicly available

Stream	Release Date	Details of outputs to date and link (if applicable) to publicly available document
1. All	**Nov 2015**	1st Annual Report. Report: "Hazelwood Health Study Annual Report 1" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1636311/hhsannualreport_final121115_v1.0.pdf
2. Community Wellbeing	**July 2016**	Abstract about social media use, presented at the 2016 ANZCA conference. Conference Proceeding: Yell et al (2016) "Communities, authority and trust in the Fifth Estate: Social media use during the Hazelwood coalmine fire". Delivered at the 2016 Australia and New Zealand Communication Association Conference on *Creating Space in the Fifth Estate*, Newcastle, 6-8 July. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
3. All	**Nov 2016**	2nd Annual Report Report: "Hazelwood Health Study Annual Report 2" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/1636424/hazelwood-health-study-2nd-annual-report-v1.1-1.pdf
4. Exposure Assessment	**Feb 2017**	CSIRO report on the modelling of the smoke exposure providing information on $PM_{2.5}$ and CO and other chemical exposures for the mine fire period. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1636434/hazelwood_airqualitymodelling_december2016_final.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1766055/Summary_AirQualityModelling_v1.1_13Feb2017.pdf
5. Older People	**Feb 2017**	Review of the impact of the Hazelwood mine fire on older people living in the Morwell community in the context of policy-driven decisions made at the time. Policy Review Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1636384/policy-review-older-people-v1.0-website.pdf Policy Brief: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/1766072/Policy-Brief-Older-People-v1.1.pdf
6. Older People	**May 2017**	Abstract on older people and communications in future disaster events submitted to Australia and New Zealand Disaster and Emergency Management Conference. Conference Proceeding: Walker & Carroll (2017) Communications in future disaster events: best practice policy for older people. Presented at the Australia and New Zealand Disaster and Emergency Management Conference, Gold Coast May 2017. (Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations

7. Psychological Impacts (Schools)	**Jun 2017**	Initial findings from the first round of the Schools Study survey comparing students from Morwell schools with those from other Latrobe Valley schools. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1636476/schools-study-analysis-of-round-1-key-quantitative-data-v1.0.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1766070/Schools-Study-Year-1-key-findings-summary-v1-170627.pdf
8. Hazelinks	**Sep 2017**	Analysis of deidentified emergency presentations and hospital admission data (1st extraction) during the smoke event compared with before and after the fire. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1636483/2018-08-20-Hospital-analysis-extract-1-technical-report.ver1.2.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/1766069/20170904-Hospital-Admissions-research-summary.pdf
9. Adult Survey	**Sep 2017**	First round of analysis comparing 3096 Morwell and 960 Sale residents who completed the HHS Adult Survey. Technical Report Volume 1. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1636395/hhsadultsurveyvol1_report_v1.1-compressed.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/1766077/20170904-Adult-Survey-research-summary.pdf
10. Hazelinks	**Sep 2017**	Analysis of cancer incidence data registered from 2009-2013 in Latrobe City compared to the surrounding LGAs to set the baseline for future comparisons. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1636482/20170919-cancer-analysis-data-extraction-technical-report-v1.0-1.pdf Research summary: https://www.monash.edu/__data/assets/pdf_file/0005/1766075/20170919-Baseline-Cancer-Analysis-research-summary-1.pdf
11. Community Wellbeing	**Sep 2017**	Paper on the use of social media during the Hazelwood mine fire. Academic paper: Yell & Duffy (2018) "Community Empowerment and trust: social media use during the Hazelwood mine fire." In the Australian Journal of Emergency Management available at https://knowledge.aidr.org.au/resources/ajem-apr-2018-community-empowerment-and-trust-social-media-use-during-the-hazelwood-mine-fire/. Full text also available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/1986931/Community-Empowerment-and-Trust_Yell-and-Duffy_ajem-33-2-21.pdf Citation and link also shown at https://hazelwoodhealthstudy.org.au/study-findings/publications
12. **Older People**	**Nov 2017**	Abstract describing the Older People Stream policy review.

		Conference Proceeding: Walker (2017). The impact of the Hazelwood mine fire in Australia on older people: review of policy-driven decisions made at the time. Aging and Society : Seventh Interdisciplinary Conference, UC Berkeley, USA, November 2017. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
13. Older People	**Nov 2017**	Abstract about older people as active participants in disaster responses. Conference Proceeding: Carroll & Walker (2017). Beyond vulnerability: Older people as active participants in disaster responses. Presented at the 50th Australian Association of Gerontology (AAG) National Conference, Perth, WA November 2017. Available at https://www.aag.asn.au/documents/item/2003 on page 37. Cited on the HHS website https://hazelwoodhealthstudy.org.au/study-findings/presentations
14. All	**Nov 2017**	3rd Annual Report Report: "Hazelwood Health Study Annual Report 3" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1636419/hazelwood-health-study-3rd-annual-report_v1.2.pdf
15. Community Wellbeing	**Dec 2017**	Paper on the politics of loss and hope in the Latrobe Valley, drawing on information from the Community Wellbeing interviews and focus groups. Academic paper: https://www.anzrsai.org/assets/Uploads/PublicationChapter/AJRS-23.3-pages-421-to-446.pdf
16. Community Wellbeing	**Dec 2017**	Video summary on the major role that social media played during the Hazelwood mine fire. Video link: http://hazelwoodhealthstudy.org.au/research-areas/community-wellbeing/ and https://youtu.be/LVwQBvaNgtM
17. Early Life Follow-up	**Jan 2018**	Volume 1 technical report on ELF survey data completed by parents of 548 children sampled across the Valley and born between 2012 and 2015. Report: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1636452/elf-vol-1_-cohortdesciption_parentreportedoutcomes-v1.2.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1766085/20180201-HHS-ELF-Volume-1-Research-Summary.pdf
18. Hazelinks	**Mar 2018**	Hazelinks technical report describing the association between $PM_{2.5}$ and data from the MBS (health service use) and PBS (pharmaceutical dispensation). Report: https://www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/2324908/Hazelinks-MBS-PBS-Technical-Report-Version-2.0.pdf. Research Summary: https://www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2324907/Hazelinks-MBS-and-PBS-Time-Series-Research-Summary-v2.0.pdf
19. Hazelinks	**May 2018**	Abstract on deidentified hospital emergency presentations and admissions presented at ATS 2018.

		Conference Proceeding Abramson et al (2018). "Emergency Presentations and Hospital Admissions Following Exposure to Smoke from a Coal Mine Fire". Available at: https://www.abstractsonline.com/pp8/#!/4499/presentation/14343 (To be listed in a new section of the HHS website)
20. Adult Survey	**May 2018**	Abstract on Adult Survey self-reported asthma and respiratory symptoms presented at ATS 2018. Conference Proceeding: Abramson et al (2018). "Adults Exposed to Coal Mine Fire Smoke Report More Asthma and Respiratory Symptoms than Those Not Exposed". Available at: https://www.abstractsonline.com/pp8/#!/4499/presentation/19606 (To be listed in a new section of the HHS website)
21. Hazelinks	**July 2018 & Mar 2020**	Paper describing the association between mine fire $PM_{2.5}$ and deidentified hospital emergency presentations and admissions (based on findings previously presented in the technical report (row 8 above). Academic paper: Guo et al (2020) The association of coal mine fire smoke with hospital emergency presentations and admissions: Time series analysis of Hazelwood Health Study" in Chemosphere, available at https://www.sciencedirect.com/science/article/pii/S0045653520308602. Citation also shown at https://hazelwoodhealthstudy.org.au/study-findings/publications. No Research Summary for this publication as a previous Research Summary was produced for the preceding technical report (see row 8 above)
22. Early Life Followup	**July 2018**	Abstract on children's lung health submitted to the Australia & New Zealand Society of Respiratory Science and the Thoracic Society of Australia and New Zealand (ANZSRS/TSANZ) Annual Scientific Meeting, July 2018. Conference Proceeding: Shao J et al. (2018). An assessment of early life exposure to coalmine fire smoke and children's lung health (abstract TOL 003). Available at https://doi.org/10.1111/resp.13267 and cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
23. Community Wellbeing	**Nov 2017 May 2018**	A travelling photographic exhibition featuring images generated by local community groups and residents symbolising their hopes for the future of Morwell. Exhibition photos: https://hazelwoodhealthstudy.org.au/media/our-hopes Exhibition catalogue: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0005/2073362/Updated-Catalogue-Final.pdf
24. Early Life Followup	**Aug 2018**	Abstract describing the association between smoking during pregnancy and early development atherosclerosis, presented to the European Cardiology Congress 2018. Conference proceeding: Zhao et al (2018) Smoking during pregnancy significantly increases the risk of early atherosclerosis: a study from coalmine smoke exposure [abstract] available at https://esc365.escardio.org/Congress/ESC-Congress-2018/Best-Posters-6-Best-Posters-in-preventive-cardiology/176295-smoking-during-pregnancy-significantly-increases-the-risk-of-early-atherosclerosis-a-study-from-coalmine-smoke-exposure#abstract also cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
25. Early Life Followup	**August 2018**	Abstract on smoke exposure during infancy and lung function submitted to ISEE 2018.

		Conference proceeding: Shao et al (2018) Exposure to Smoke from a Coal Mine Fire during Infancy and Lung Function Three Years after the Event. Available at https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.P02.1800 and cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
26. Psychological Impacts (Adult)	**Aug 2018**	Paper summarising the findings from qualitative interviews with adult Morwell residents on the social and psychological impacts of the event. Academic paper: Jones et al 2018 "Experiences of a prolonged coal-mine fire. In Disaster Prevention and Management. Available by subscription https://doi.org/10.1108/DPM-05-2018-0145. Pre-print version freely available at https://research.monash.edu/files/252507394/252145312_oa.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1766079/20180605-adults-Psych-stream-research-summary-4.pdf
27. Hazelinks	**Aug 2018**	Abstract on $PM_{2.5}$ and PBS data submitted to ISEE 2018 Conference Proceeding: Johnson et al (2018) Fine particulate matter and medications dispensed during and after a brown coal mine fire: a time series analysis. Presented at the International Society of Exposure Science and International Society for Environmental Epidemiology 2018 Joint Annual Meeting. 26–30 August 2018, Ottawa, Canada. Available at https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.P02.1550 (To be listed in a new section of the HHS website)
28. Hazelinks	**Aug 2018**	Abstract on $PM_{2.5}$ and Medicare health service data submitted to ISEE 2018. Conference Proceeding: Johnson et al (2018) Brown coal mine fire-related fine particulate matter and medical service utilisation in Australia: a time series analysis. Presented at the International Society of Exposure Science and International Society for Environmental Epidemiology 2018 Joint Annual Meeting, Ottawa, Canada, 26–30 August 2018. Available at https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.O02.04.19 (To be listed in a new section of the HHS website)
29. Psychological Impacts (Schools)	**Sep 2018**	Paper on the perception of staff from a specialist school on the impacts of the smoke and relocation on students and staff at the school. Academic paper: Berger et al (2018) "Disaster Impacts on Students and Staff from a Specialist, Trauma-Informed Australian School" in Journ Child Adol Trauma. Available by subscription at https://doi.org/10.1007/s40653-018-0228-6. Full text freely avail on pre-print server at: https://doi.org/10.31234/osf.io/agdb5 Link also provided at https://hazelwoodhealthstudy.org.au/study-findings/publications Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/1766080/20180910-Psychological-Impacts-Stream-Specialist-School-Interviews-Research-Summary.pdf
30. Psychological Impacts (Schools)	**Sep 2018**	Analysis of round 1 Schools Study interviews on the impacts of the mine fire on students. Academic publication: Berger et al (2020) "Children's Perspectives on the Impact of the Hazelwood Mine Fire and Subsequent Smoke Event". Child & Youth Care Forum. Available by subscription from: https://doi.org/10.1007/s10566-020-09551-8. Pre-print version available at https://doi.org/10.31234/osf.io/8mhxf (also https://psyarxiv.com/8mhxf/) Link also provided at https://hazelwoodhealthstudy.org.au/study-findings/publications

		Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1766083/20180906-Psychological-Impacts-Stream-Childrens-perspectives.pdf
31. Early Life Follow-up	**Oct 2018**	ELF Technical Report Volume 2 reporting on the clinical assessments looking at the relationship between smoke exposure and respiratory functioning. Technical Report: Link provided at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/2052516/ELFVol-2-Lung-Function-Testing-v1.1.pdf Research summary: One Research Summary which combines the findings from ELF Volumes 2 and 3 is available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0005/1766102/ELF-vols-2_3-Research-Summary.pdf
32. Early Life Follow-up	**Oct 2018**	ELF Technical Report Volume 3, reporting on the clinical assessments looking at the relationship between smoke exposure and cardiovascular functioning. Technical Report: Zhao et al (2018) "The Latrobe Early Life Follow-up (ELF) Cohort Study Volume 3 Investigation of possible associations between coal mine fire emissions and vascular outcomes in the ELF cohort three years after the fire" Link provided at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/2150547/ELF-Cohort-Study_Volume-3-CV-Report_v1.1.pdf Research summary: One Research Summary which combines the findings from ELF Volumes 2 and 3 is available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0005/1766102/ELF-vols-2_3-Research-Summary.pdf
33. Early Life Followup	**Nov 2018**	Abstract presented to the American Heart Association Scientific Sessions 2018 on normal ranges of IMT in young children. Followed by a paper on this same subject, submitted to Pediatric Cardiology. Conference Proceeding: Zhao et al, (2018) Feasibility and Normal Ranges of Arterial Intima-Media Thickness and Stiffness in 2-Year-Old Children. Available at https://www.ahajournals.org/doi/10.1161/circ.138.suppl_1.13237 and cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations Academic paper: Zhao et al (2019). "Feasibility and Normal Ranges of Arterial Intima-Media Thickness and Stiffness in 2-Year-Old Children: A Pilot Study" in Pediatric Cardiology. Available by subscription at https://link-springer-com.ezproxy.lib.monash.edu.au/content/pdf/10.1007/s00246-019-02088-1.pdf. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications.
34. Psychological Impacts (Adult)	**Nov 2018**	Paper on adult psychological outcomes which combined analysis of Adult Survey findings with follow up face to face interviews. Academic paper: Maybery et al (2020) "A mixed-methods study of psychological distress following an environmental catastrophe: the case of the Hazelwood open-cut coalmine fire in Australia" in Anxiety, Stress, & Coping. Available by paid subscription at https://www.tandfonline.com/doi/abs/10.1080/10615806.2019.1695523 Full text also available on a preprint server at: https://psyarxiv.com/euj96/ Citation also shown at https://hazelwoodhealthstudy.org.au/study-findings/publications Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1766101/Psych-stream-mixed-methods-research-summary-V2.pdf

35. All	**Nov 2018**	4th Annual Report Report: "Hazelwood Health Study Annual Report 4" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1636251/hhs-4th-annual-report-v1.0.pdf
36. Hazelinks	**Dec 2018**	Report on risk of ambulance attendances during the Hazelwood mine fire compared with before and after the event (1st extraction, deidentified data). Report version 1.0 placed on https://hazelwoodhealthstudy.org.au/study-findings/study-reports in Dec 2018 but removed in Feb 2020 for revisions to be made. Report version 1.1 listed on https://hazelwoodhealthstudy.org.au/study-findings/study-reports in March 2020 as being available upon request by calling 1800 985 899 or emailing contact@hazelwoodhealthstudy.org.au Research summary: available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1766100/Ambulance-attendances-during-the-Hazelwood-mine-fire.pdf Refer row 63 for the academic paper based on these findings.
37. Early Life Follow-up	**Dec 2018**	Paper on birth outcomes in the Latrobe Valley following the mine fire based on analysis of anonymous Victorian Perinatal Data Collection records. Academic paper: Melody et al (2019) Maternal exposure to fine particulate matter from a coal mine fire and birth outcomes in Victoria, Australia. Published in Environment International .Full text available at https://doi.org/10.1016/j.envint.2019.03.028 and citation shown at https://hazelwoodhealthstudy.org.au/study-findings/publications Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1766097/Birth-outcomes-using-anonymous-Victorian-Perinatal-Data-Collection-Records.pdf
38. Adult Survey	**Jan 2019**	Second round of analysis on the Adult Survey looking at the relationship between level of smoke exposure and health outcomes. Technical Report Volume 2. Report: Ikin et al (2019) Hazelwood Health Study Adult Survey Volume 2: The relationship between Hazelwood mine fire smoke exposure and health outcomes. Available on the HHS website at: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/1636460/hazelwoodhealthstudy-adult-survey-volume-2-report-v1.1.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1766094/20190123-Adult-Survey-Volume-2-Research-Summary.pdf
39. Psychological Impacts (Schools)	**March 2019**	Report on the second round of face to face interviews with students participating in the Schools Study tracking ongoing impacts. Report: Allen et al (2019) Hazelwood Health Study Schools Study: Report of Round 2 Qualitative Findings available on the HHS website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/1766135/Schools-Study-Round2-Interviews.pdf Research summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/1766104/Research-Summary-Schools-Study-Round-2-Interviews.pdf
40. Hazelinks	**Mar 2019**	Paper based on revised analysis of PBS data (see row 18 above) assessing the relationship between smoke exposure and medication dispensing. Academic paper: Johnson et al (2019) "Fine particulate matter exposure and medication dispensing during and after a coal mine fire: A time series analysis from the Hazelwood Health Study". Available by subscription at https://doi.org/10.1016/j.envpol.2018.12.085. Citation also shown at

		https://hazelwoodhealthstudy.org.au/study-findings/publications with readers advised to email contact@hazelwoodhealthstudy.org.au to request a full copy of the paper. No Research Summary for this publication as a previous Research Summary was produced for the preceding technical report (see row 18 above)
41. Psychological Impacts (Schools)	**Mar 2019**	Paper on the first round of the Schools Study combining analysis of survey and interview findings. Academic paper: Maybery et al (2019) The psychological impact and experiences of children following the Hazelwood mine fire and subsequent smoke event. Preprint version available at https://psyarxiv.com/rw657 Cited on the HHS website at: https://hazelwoodhealthstudy.org.au/study-findings/publications. Subsequently, this paper has been extensively revised and re-titled "Posttraumatic stress among school-aged students following a mine fire." The revised manuscript has been published by the *Journal of Aggression, Maltreatment and Trauma* and is available at www.tandfonline.com/doi/abs/10.1080/10926771.2023.2228240. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/1766104/Research-Summary-Schools-Study-Round-2-Interviews.pdf
42. Community Wellbeing	**May 2019**	CWB Stream Technical Report Volume 1 (Version 1.0 of this report replaced with version 2.0 in October 2019) Report: Yell et al (2019) Community Wellbeing Stream Report Volume 1: Community perceptions of the impact of the smoke event on community wellbeing and of the effectiveness of communication during and after the smoke event. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0018/2052540/CW-Report-Volume-1_v2.0.pdf Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1766103/community-perceptions-of-the-impact.pdf
43. Early Life Follow-up	**May 2019**	Paper on the relationship between mine fire smoke and risk of pregnancy-related health outcomes incl gestational diabetes. Academic paper: Melody et al (2019) "Maternal exposure to fine particulate matter from a large coal mine fire is associated with gestational diabetes mellitus: A prospective cohort study" published in *Environmental Research* and available by subscription at https://doi.org/10.1016/j.envres.2019.108956 Full citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications; website viewers invited to request a copy of the paper by emailing contact@hazelwoodhealthstudy.org.au Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1795830/Research-Summary-ELF-Exposure-to-mine-fire-smoke-and-the-risk-of-pregnancy-related-health-problems.pdf Abstract submitted to the World Congress of Epidemiology 2020 (which was cancelled)
44. Early Life Follow-up	**May 2019**	ELF Technical Report Volume 4 on updated analysis of birth outcomes using additional information provided by parents and maternal health data.

		Report: Melody et al (2019) https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/2052517/Latrobe-ELF-tech-report-volume-4_v1.0.pdf Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/2052562/Research-Summary-ELF-Repeat-analysis-of-birth-outcomes.pdf Abstract submitted to the World Congress of Epidemiology 2020.
45. Early Life Followup	**May 2019**	Abstract on nitrogen dioxide and lung function, submitted to the American Thoracic Society Scientific Meeting, Conference Proceeding: Shao et al (2019) " Ambient Nitrogen Dioxide Exposure During Infancy Influences Respiratory Mechanics in Preschool Years [Abstract]" published in the American Journal of Respiratory and Critical Care Medicine available by paid subscription at https://doi.org/10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A7058. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations
46. Respiratory	**July 2019**	Paper examining whether exposure to smoke from the mine fire is associated with respiratory symptoms, asthma control and decline in lung function. Academic paper: Taylor et al (2019) "Is asthma associated with exposure to smoke from a coal mine fire?" Pre-print available at: https://www.biorxiv.org/content/10.1101/631317v1 Pre-print citation and link provided on HHS website shown at https://hazelwoodhealthstudy.org.au/study-findings/publications Nb. as of 17/3/20, this paper was yet to be published in a scientific journal. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0019/1840024/Research-Summary-Respiratory-Stream-Lung-Function-and-Asthma-Impacts.pdf
47. Hazelinks	**Oct 2019**	Paper describing revised analysis (see row 18 above) of the association between $PM_{2.5}$ and Medicare health service use. Academic paper: Johnson et al. (2020) "Coal-mine fire-related fine particulate matter and medical-service utilization in Australia: a time-series analysis from the Hazelwood Health Study" in the International Journal of Epidemiology. Full text available by subscription at https://doi.org/10.1093/ije/dyz219. Citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications and readers may request a full copy by emailing contact@hazelwoodhealthstudy.org.au No Research Summary for this publication as a previous Research Summary was produced for the preceding technical report (see row 18 above)
48. Cardiovascular	**Oct 2019**	Paper aiming to estimate the prevalence of hypertension in the cohort and identify predictors of hypertension management (does not address any research question about the impact of the mine fire) Academic paper: Betts et al (2020) "Factors associated with hypertension and its management among older rural Australians" published in the Australian Journal of Rural Health (May 2020) 28(4), 399-407. Full text available by subscription at https://doi.org/10.1111/ajr.12634. Citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications and readers may request a full copy by emailing contact@hazelwoodhealthstudy.org.au

		Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0016/2011831/CVD-Hypertension-Research-Summary.pdf The Research Summary invites readers to request the full copy of the paper by calling 1800 985 899 or emailing contact@hazelwoodhealthstudy.org.au
49. Cardiovascular	**Oct 2019**	Paper aiming to measure any association between mine fire $PM_{2.5}$ and CVD risk factors. Academic paper: Betts et al (2021) "Markers of cardiovascular disease among adults exposed to smoke from the Hazelwood coal mine fire" published in the International Journal of Environmental Research and Public Health, 18(4), 1587. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications and freely available at https://doi.org/10.3390/ijerph18041587. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0015/2011830/CVD-Blood-Vessel-Health-Research-Summary-1.pdf
50. Adult Survey	**Oct 2019**	Abstract submitted to the European Respiratory Society International Congress on $PM_{2.5}$ and chronic cough. Conference Paper: Abramson et al (2019) "Chronic cough is related to cumulative $PM_{2.5}$ and exposure from a coal mine fire [abstract]" available at https://erj.ersjournals.com/content/54/suppl_63/PA4455 and cited on the HHS website https://hazelwoodhealthstudy.org.au/study-findings/presentations
51. Respiratory	**Nov 2019**	Abstract describing the association between $PM_{2.5}$ and COPD based on adult Respiratory Stream clinic data. Submitted to the ATS 2020. Conference Proceeding: Prasad SR, Borg B, Gao CX et al (2020) Chronic Obstructive Pulmonary Disease Is Associated with Exposure to Fine Particles from a Coal Mine Fire [abstract]. Accepted as an e-poster for inclusion in the American Thoracic Society 2020 Virtual meeting. Also published in the American Journal of Respiratory and Critical Care Medicine; 201:A7835. https://www.atsjournals.org/doi/abs/10.1164/ajrccm-conference.2020.201.1_MeetingAbstracts.A7835
52. Exposure Assessment	**Nov 2019**	Paper written by CSIRO describing the modelling of $PM_{2.5}$ data. Academic paper: Luhar et al (2020) Modelling smoke distribution in the vicinity of a large and prolonged fire from an open-cut coal mine. Atmospheric Environment, 117471. Available from http://www.sciencedirect.com/science/article/pii/S1352231020302089. Citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications No Research Summary for this paper as it replicates CSIRO's modelling report and Research Summary described in Row 4 above.
53. All	**Nov 2019**	5th Annual Report Report: "Hazelwood Health Study Annual Report 5" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2052828/HHS-5th-Annual-Report-v-1.0-with-Appendices.pdf
54. Adult Survey/ Psychological Impacts	**Dec 2019**	Paper describing the association between $PM_{2.5}$ and symptoms of distress and contributing factors Academic paper: Broder et al (2020) "The factors associated with distress following exposure to smoke from an extended coal mine fire" published in *Environmental Pollution 266*, 115131. Available by paid subscription at

		https://doi.org/10.1016/j.envpol.2020.115131 or http://www.sciencedirect.com/science/article/pii/S0269749119373907. To request a free copy of the paper call 1800 985 899 or email contact@hazelwoodhealthstudy.org.au. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2052585/Long-term-psychological-health-following-the-Hazelwood-mine-fire.pdf
55. Community Wellbeing	**Dec 2019**	CWB Stream Technical Report Volume 2 on the community perceptions of effectiveness of community rebuilding activities. Report: Yell et al (2019) Community Wellbeing Stream Report Volume 2: Community perceptions of the effectiveness of community rebuilding activities https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2059236/CW-Report-Volume-2_version-1.0.pdf Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/2058960/Research-Summary-Community-perceptions-of-the-effectiveness-of-community-rebuilding-activities.pdf
56. Early Life Followup	**Nov 2019**	Paper describing association between smoke and health service and medication usage in children. Academic paper: Shao et al (2020) "Exposure to air pollution during the first 1000 days of life and subsequent health service and medication usage in children" published by Environmental Pollution. Available by subscription at https://doi.org/10.1016/j.envpol.2019.113340. Full citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications; website viewers invited to request a copy of the paper by emailing contact@hazelwoodhealthstudy.org.au Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/2052568/ELF-Research-Summary-GP-visits-and-medication-use.pdf
57. Early Life Followup	**Dec 2019**	Paper describing the association between exposure to coal mine fire and tobacco smoke, and subclinical vascular function in young children. Academic paper: Zhao et al 2019 "Early life exposure to coal mine fire and tobacco smoke affect subclinical vascular function" published in Archives of Disease in Childhood. Available by subscription at https://adc.bmj.com/content/early/2019/12/20/archdischild-2019-317528. Full citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications; website viewers invited to request a copy of the paper by emailing contact@hazelwoodhealthstudy.org.au
58. Early Life Followup	**Dec 2019**	Technical Report, Research Summary and paper describing the association between $PM_{2.5}$ and common illnesses like coughs, colds and asthma based on parent-reported monthly diaries. Report: Willis et al (2019) Latrobe Early Life Follow-up (ELF) Cohort Study Volume 6. The impact of exposure to coal mine fire smoke in early life on parent-reported indicators of childhood atopic and respiratory illness. Version 1.0. Available upon request by calling 1800 985 899 or emailing contact@hazelwoodhealthstudy.org.au Academic paper: Willis et al (2020) "Respiratory and atopic conditions in children two to four years after the 2014 Hazelwood coalmine fire" in the Medical Journal of Australia, 2020, vol 213(6), pp 269-275. Freely available at

		https://doi.org/10.5694/mja2.50719. Link also shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications Research Summary: available on the HHS website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/2052569/2019.09-Monthly-diary-summary-for-participants-.pdf The Research Summary invites readers to request the full copy of the technical report by calling 1800 985 899 or emailing contact@hazelwoodhealthstudy.org.au
59. Adult Survey	**Dec 2019**	Paper based upon the Adult Survey, respiratory symptoms, building materials and $PM^{2.5}$ Academic paper: Johnson et al (2019) Associations between Respiratory Health Outcomes and Coal Mine Fire $PM_{2.5}$ Smoke Exposure: A Cross-Sectional Study. In the International Journal of Environmental Research and Public Health. Available at https://www.mdpi.com/1660-4601/16/21/4262 Also cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications
60. Hazelinks	**Jan 2020**	Technical report describing the association between mortality, the mine fire period and $PM_{2.5.}$ Report: v1.0 submitted to DHHS in November 2019 and resubmitted as v1.1 in February 2020. Report and accompanying Q and A document freely available on the Hazelwood Health Study website at https://hazelwoodhealthstudy.org.au/study-findings/study-reports Research Summary: https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries
61. Early Life Followup	**Feb 2020**	Paper describing association between smoke and lung function in young children. Academic paper: Shao et al (2020) "Early life exposure to coal mine fire smoke emissions and altered lung function in young children" in *Respirology*. Available by subscription at https://doi.org/10.1111/resp.13617. Full citation shown on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications; website viewers invited to request a copy of the paper by emailing contact@hazelwoodhealthstudy.org.au
62. Cardiovascular	**Mar 2020**	Paper describing the relationship between diet quality scores and cardiometabolic risk factors in regionally-dwelling older Australian adults with increased cardiovascular risk. Academic paper: Owen et al (2020) Recommended Intake of Key Food Groups and Cardiovascular Risk Factors in Australian Older, Rural-Dwelling Adults. Published in *Nutrients*. Freely available at https://www.mdpi.com/2072-6643/12/3/860/htm and on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications As this publication does not address a Hazelwood Health Study research question, a HHS Research Summary has not been prepared.
63. Hazelinks	**April 2020**	Paper describing the association between $PM_{2.5}$ and deidentified ambulance data (based on analysis previously presented in the technical report (see row 36 above). Academic paper: Gao Et Al "Impact of acute exposure to mine fire emitted $PM_{2.5}$ on ambulance attendances: a time series analysis from the Hazelwood Health Study" in *Environmental Research*, 110402. Available by subscription at https://doi.org/10.1016/j.envres.2020.110402. For a free copy of this article, please email contact@hazelwoodhealthstudy.org.

		No Research Summary as findings were previously presented (see row 36)
64. Adult Survey	**April 2020**	Paper describing the establishment, recruitment and followup of the HHS adult cohort. Academic paper: Ikin et al "Cohort Profile: The Hazelwood Health Study adult cohort" in the *International Journal of Epidemiology*. Available by subscription at https://doi.org/10.1093/ije/dyaa083. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. A free copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au No Research Summary released with this publication as it does not present new findings.
65. Psychological Impacts (Schools)	**April 2020**	Paper describing Schools Study participants, linked NAPLAN data and CRIES measures. Academic paper: Berger at al "The Impact of a Mine Fire and Smoke Event on Academic Outcomes for Primary and Secondary School Students" in *Psychological Trauma: Theory, Research, Practice, and Policy*. Available by subscription at www.doi.org/10.1037/tra0001179. Pre-print freely available at https://psyarxiv.com/unms5/. Pre-print link provided on the HHS website at www.hazelwoodhealthstudy.org.au/study-findings/publications. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0018/2232054/20201606-NAPLAN-The-Impact-of-a-Mine-Fire-and-Smoke-Event-on-Academic-Outcomes-for-Primary-and-Secondary-School-Students.pdf
66. Respiratory Stream	**May 2020**	Abstract describing the association between $PM_{2.5}$ and COPD submitted to the American Thoracic Society Annual Meeting 2020. Nb. the Meeting was replaced with ATS Virtual. The abstract has been accepted and published. Conference Proceeding: Prasad et al (2020) Chronic Obstructive Pulmonary Disease Is Associated with Exposure to Fine Particles from a Coal Mine Fire [abstract]. *American Journal of Respiratory and Critical Care Medicine*; 201:A7835. Available at https://www.atsjournals.org/doi/abs/10.1164/ajrccm-conference.2020.201.1_MeetingAbstracts.A7835. Also cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations.
67. Early Life Followup	**June 2020**	Paper describing the establishment, recruitment and followup of the HHS Early Life Followup cohort. Academic paper: Melody et al. "Cohort Profile: The Hazelwood Health Study Latrobe Early Life Follow-Up (ELF) Study" in the *International Journal of Epidemiology* 2020. Available by subscription https://doi.org/10.1093/ije/dyaa136. Cited on the website at https://hazelwoodhealthstudy.org.au/study-findings/publications. A free copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au. No Research Summary released with this publication as it does not present new findings.
68. Respiratory Stream	**July 2020**	Paper and conference abstract describing the association between $PM_{2.5}$ and lung mechanics using the forced oscillation technique (FOT) in the adult Respiratory Stream.

		Academic paper: Holt et al. (2021) "Long term impact of coal mine fire smoke on lung mechanics in exposed adults" in Respirology. Available by subscription at https://onlinelibrary.wiley.com/doi/10.1111/resp.14102. Pre-print version freely available at https://doi.org/10.1101/2020.10.14.20213009. Pre-print link also cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. Conference Proceeding: Holt et al Altered lung mechanics after coal mine fire smoke exposure in adults. Abstract accepted by ERS International Virtual Congress 2020. In European Respiratory Journal, 56(suppl 64), 3146. https://doi.org/10.1183/13993003.congress-2020.3146 Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/2351096/Research-Summary_RespStream_FOT-paper.pdf
69. Hazelinks	**Aug 2020**	Paper describing the describing the association between $PM_{2.5}$ and linked ambulance attendance data in consented Adult Survey participants. Academic paper: Broder et al. Long-term impact of exposure to coalmine fire emitted PM2·5 on emergency ambulance attendances: Hazelwood Health Study. (2021) Published by *Chemosphere*. Available by subscription at doi.org/10.1016/j.chemosphere.2021.132339. Cited on the HHS website and a free copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0012/2351100/Hazelinks-Research-summary_linked-ambulance-paper.pdf
70. Respiratory Stream	**Aug 2020**	Paper describing the association between $PM_{2.5}$ and COPD, $T_L$co and symptoms in adult Resp Stream participants. Same findings as those presented in the abstract at row 66 above. Academic paper: Prasad et al. "Chronic Obstructive Pulmonary Disease is associated with exposure to fine particles from a coal mine fire" published by the journal *Annals of the American Thoracic Society*. Available by subscription at www.atsjournals.org/doi/10.1513/AnnalsATS.202012-1544OC. Pre-print version freely available at https://doi.org/10.1101/2020.10.14.20213009. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/2351095/Research-Summary_RespStream_COPD-paper.pdf
71. Adult Survey/ Psych Impacts	**Oct 2020**	Paper describing the association between psychological distress and respiratory symptoms in the context of the mine fire. Not a Hazelwood Health Study research question. Academic paper: Samuel et al "Associations between self-reported respiratory symptoms and psychological distress following exposure to a landscape fire" 2021 published in *Stress and Health*. Available by subscription at https://doi.org/10.1097/EE9.0000000000000042. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. A free copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au Conference proceeding: Poster accepted for TSANZ Vic 2020. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/presentations.

		No Research Summary released with this publication as it does not address a HHS research question.
72. Adult Psych Impacts	**Nov 2020**	Paper and abstract describing psychological distress in young adults. Academic paper: O'Donohue et al (2022) "The psychological impacts of a smoke event on young adults compared to other aged adults in Victoria, Australia". Published in the *Int Jnl Risk Reduction*. Freely available at www.doi.org/10.1016/j.ijdrr.2021.102727 Conference Proceeding: abstract accepted for presentation at the 4th International Childhood Trauma Conference held in Melbourne, Australia in August 2022. No Research Summary released with this publication.
73. Adult Psych Impacts	**Nov 2020**	Technical report describing the initial analysis of data from the 2019-2020 Mental Health and Wellbeing Follow-up Survey. Report: Carroll M. et al (2020). Hazelwood Health Study Technical Report. 2019-2020 Mental Health and Wellbeing Follow-up Survey: A follow-up to the 2016-2017 Adult Survey investigating the ongoing psychological health of adults who lived in Morwell during the 2014 Hazelwood mine fire. Freely available on the Hazelwood Health Study website at https://hazelwoodhealthstudy.org.au/study-findings/study-reports Research Summary: Reseach-summary-Mental-Health-Follow-up-Report-07122020.pdf (hazelwoodhealthstudy.org.au)
74. Early Life Followup	**Nov 2020**	Technical report describing the sources of air pollution to which ELF families were exposed. Report: Chappell K et al (2020) The Latrobe Early Life Follow-up (ELF) Cohort Study Volume 5. A description of sources of air pollution inside and outside the home environments of children in the Latrobe ELF Cohort. Available on the Hazelwood Health Study website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/2424871/ELF-Report-Vol-5_Version1.0.pdf No Research Summary released with this publication as it does not address a HHS research question.
75. Early Life Followup	**Nov 2020**	Paper describing the association between respiratory and cardiovascular function in young children. Academic paper: Hemstock E et al (2021). Associations between respiratory and cardiovascular function in early childhood. Published by the journal *Respirology* and cited on the HHS website at www.hazelwoodhealthstudy.org.au/study-findings/publications. Available by subscription at https://doi.org/10.1111/resp.14117 or a free copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au. No Research Summary released with this publication as it does not address a HHS research question.
76. All	**Nov 2020**	6th Annual Report Report: "Hazelwood Health Study Annual Report 6" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/2452866/HHS-6th-Annual-Report-v1.0.pdf
77. Respiratory Stream	**Dec 2020**	Paper describing the characteristics of e-cigarette users.

		Academic paper: Lee WK et al (2021) Are E-cigarette use and vaping associated with increased respiratory symptoms and poorer lung function in a population exposed to smoke from a coal mine fire? Published in *Respirology* and cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. Available by subscription at https://doi.org/10.1111/resp.14113 or a copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au. No Research Summary released with this publication as it does not address a HHS research question.
78. Psych Impacts Schools	**Feb 2021**	Paper describing analysis of deidentified NAPLAN data Academic paper: Gao CX et al (2023). Evaluating the impact of Hazelwood mine fire event on students' educational development with Bayesian interrupted time-series hierarchical meta-regression. Published in March 2023 by the journal *PLoS ONE* and freely available at https://doi.org/10.1371/journal.pone.0281655. A preprint version is also available at https://doi.org/10.1101/2021.03.28.21254516. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/2560378/Deidentified-NAPLAN_Research-Summary.pdf
79. Hazelinks	**Mar 2021**	Paper describing hospital admission data linked to Adult Survey participants. Academic paper: Xu R et al (2021) Long-term impacts of coal mine fire emitted $PM_{2.5}$ on hospitalization: a longitudinal analyses of the Hazelwood Health Study. Published by the *International Journal of Epidemiology* and available at https://doi.org/10.1093/ije/dyab249. Cited on the website at https://hazelwoodhealthstudy.org.au/study-findings/publications. A copy of the paper can be requested by emailing contact@hazelwoodhealthstudy.org.au. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/2552263/Linked-Hospital-Paper-Research-Summary.pdf
80. Cardiovascular	**April 2021**	Paper describing the flow mediated dilatation results from CVD Stream round 1 clinical testing. Academic paper: Mundisugih et al (2021) "Vascular responses among adults exposed to smoke from the Hazelwood coal mine fire". Published in *Vascular Health and Risk Management* and freely available at www.doi.org/10.2147/VHRM.S339439. Cited on the website at https://hazelwoodhealthstudy.org.au/study-findings/publications. No Research Summary released with this publication because the findings are very similar to those previously reported (refer row 49 above).
81. Adult Psych Impacts	**May 2021**	Literature review exploring the psychological outcomes for young adults after disaster events Academic paper: O'Donohue et al (2021) "Psychological outcomes for young adults after disastrous events: A mixed-methods scoping review". Published by Social Science & Medicine. Available by subscription https://doi.org/10.1016/j.socscimed.2021.113851. No Research Summary released with this publication as it does not address a HHS research question.

82. Hazelinks	**June 2021**	Paper describing the results from the previously release mortality report (refer row 60 above). Academic paper: Dimitriadis et al (2021) "Exposure to mine fire related particulate matter and mortality: A time series analysis from the Hazelwood Health Study" published in *Chemosphere.* Available by subscription at https://doi.org/10.1016/j.chemosphere.2021.131351. The more detailed report (refer row 60 above) and a FAQ document is freely available on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/study-reports. Research Summary: the Research Summary for the previously released report (refer row 60 above) is available on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries.
83. Adult Psych Impacts	**July 2021**	Paper based on mental health related ambulance, emergency department presentations & hospital admissions. Academic paper: Carroll et al (2022) "Impacts of coal mine fire-related $PM_{2.5}$ on the utilisation of ambulance and hospital services for mental health conditions" published in *Atmospheric Pollution Research.* Available by subscription at: https://doi.org/10.1016/j.apr.2022.101415. A free pre-print version of this paper (not externally peer reviewed) is available at https://psyarxiv.com/hgv7t/ Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2745873/Research-Summary_AdultPsych_HospitalAmbulance.pdf
84. Hazelinks	**July 2021**	A short paper regarding the incidence of cancer in the 5 years after the Hazelwood mine fire. Academic paper: Yu et al (2021) "Impacts of high concentration, medium duration coal mine fire related $PM_{2.5}$ on cancer incidence: 5-year follow-up of the Hazelwood Health Study". Published by *Environmental Health Insights*. Freely available at https://journals.sagepub.com/doi/10.1177/11786302211059722. Cited on the HHS website at https://hazelwoodhealthstudy.org.au/study-findings/publications. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/2718962/Research-Summary_linked-cancer-5years-v1.0-1.pdf
85. Adult Psych Impacts	**July 2021**	Paper exploring the ongoing psychological distress associated with exposure to smoke during the 2014 Hazelwood coal mine fire. This is based on the previously released Technical report describing the initial analysis of data from the 2019-2020 Mental Health and Wellbeing Follow-up Survey (refer row 73). Academic paper: Carroll et al (2022) "An exploration of the trajectory of psychological distress associated with exposure to smoke during the 2014 Hazelwood coal mine fire". Published by the *International Journal of Hygiene and Environmental Health*. Freely available until 16 April 2022 at https://authors.elsevier.com/c/1eel8574Px5z6b. Available by subscription at https://doi.org/10.1016/j.ijheh.2022.113946. Cited on the website at https://hazelwoodhealthstudy.org.au/study-findings/publications. A pre-print version of this paper (not externally peer reviewed) is available at https://doi.org/10.31234/osf.io/tz5c4 Research Summary: the Research Summary for the previously released report (refer row 73 above) is available on the HHS website at

		https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries
86. All	**Nov 2021**	7th Annual Report Report: "Hazelwood Health Study Annual Report 7" available at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/2834399/HHS-7th-Annual-Report-v1.0.pdf
87. Hazelinks	**Dec 2021**	A short commentary describing findings in regard to the association between $PM_{2.5}$ exposure and Emergency Department presentations linked to Adult Survey participants. Academic paper: Smith et al "Long-term impact of exposure to the 2014 Hazelwood coal mine fire on emergency department presentations in Australia". Published by *Environmental Research*. Freely available at https://doi.org/10.1016/j.envres.2023.115440 Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2881458/Linked-emergency-dept-presentations.pdf
88. Early Life Followup	**Mar 2022**	Based on the ELF Study's round 2 clinical data, this abstract describes the association between in-utero $PM_{2.5}$ exposure and lung mechanics 7 years later. Conference proceeding: Hemstock et al "Prenatal exposure to emissions from a coalmine fire and childhood lung function." Accepted for presentation at three conferences; the Centre for Air Pollution, Energy and Health Research Symposium in May 2022 (oral presentation); the International Society for Environmental Epidemiology Asia and Western Pacific Chapter & International Society for Exposure Science in Asia Chapter in June 2022 (poster); the 34th Annual Conference of the International Society for Environmental Epidemiology in September 2022 (poster). The abstract is available at https://ehp.niehs.nih.gov/doi/abs/10.1289/isee.2022.P-0422. Formal citations not yet available. The poster is available on the HHS website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0005/3078446/Poster_HemstockEtAl_2022_ELF-PrenatalPM-exposure_lung-function.pdf. Research Summary: NA
89. Early Life Followup	**Mar 2022**	An abstract describing the association between in-utero and infant $PM_{2.5}$ exposure and subsequent hospital emergency department presentations and admissions. Conference proceeding: Ziou et al "Early life exposure to coal smoke and hospital visitation: findings from a data linkage cohort study". Accepted and presented as a poster at the 2022 Annual conferences of the International Society for Environmental Epidemiology. Awaiting formal citation. The abstract is available at https://ehp.niehs.nih.gov/doi/abs/10.1289/isee.2022.P-0441 The poster is available on the HHS website at https://www.monash.edu/hazelwood-health-study/study-findings/presentations?a=3076583 Research Summary: NA

90. Early Life Followup	**Mar 2022**	An abstract describing the association between in-utero and infant $PM_{2.5}$ exposure, and subsequent primary care medical service use and prescribed medications. Conference proceeding: Ziou et al "Prenatal and early postnatal exposure to air pollution associations with primary care and prescription usage". Accepted and presented as a poster at the 2022 Annual conferences of the International Society for Environmental Epidemiology. Awaiting formal citation. The poster is available on the HHS website at https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/3076589/Poster_ZiouEtAl_ISEE2022_544_PM-exposure_Primary-care_prescriptions.pdf Research Summary: NA
91. Adult Psychological Impacts	**April 2022**	A paper describing explore the role of Hazelwood mine fire-related posttraumatic stress, and general psychological distress, in the presentation of physical symptoms such as pain, fatigue, shortness of breath and gastrointestinal problems experienced during the 2019-2020 Black Summer bushfires. Academic paper: Gao et al "Somatic symptoms, psychological distress and trauma in response to climate disasters: lessons from the 2014 Hazelwood mine fire and 2019-20 Black Summer bushfires." Published by *BMC Public Health* in August 2023 and freely available at https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-16501-1. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/2997033/May-2022-Physical-symptoms.pdf
92. Early Life Followup	**July 2022**	A paper based on the ELF Study round 2 clinical assessments, describing the lack of an association between in utero exposure to mine fire smoke and lung function 7 years later. Academic paper: Hemstock et al (2023) "No association between in utero exposure to emissions from a coalmine fire and post-natal lung function." Published in April 2023 by *BMC Pulmonary Medicine* and freely available at www.bmcpulmmed.biomedcentral.com/articles/10.1186/s12890-023-02414-7 Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2999232/July-2022-Childhood-lung-function.pdf
93. Early Life Followup	**Sept 2022**	Abstract describing longitudinal analysis of ELF Study round 1 and 2 FOT and IMT data. Conference proceeding: Hemstock et al (2023). "The Health Impacts of Exposure to Air Pollution in Early Childhood". Presented to the Annual Scientific Meeting for Leaders in Lung Health & Respiratory Science scheduled for 25-28th March 2023. Proceedings published by *Respirology*, 28: 28-109. www.doi.org/10.1111/resp.14459. Research Summary: NA

94. Early Life Followup	**Sept 2022**	Manuscript describing early life exposure to mine fire smoke and associated emergency department presentations and hospital admissions. Academic paper: Ziou et al (2022). "Contrasting health outcomes following a severe smoke episode and ambient air pollution in early life: Findings from an Australian data linkage cohort study of hospital utilisation." Accepted in October 2023 for publication in *Environmental Health Perspectives*. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0020/3110843/November-2022-Emergency-department-visits-and-hospital-admissions-among-exposed-infants.pdf
95. Respiratory Stream	**Oct 2022**	Abstract describing adult Respiratory Stream round 1 clinic MBNW results. Conference proceeding: McCrabb et al (2023) "Increased conductive ventilation heterogeneity following exposure to coal-mine fire smoke." Presented to the *Annual Scientific Meeting for Leaders in Lung Health & Respiratory Science* scheduled for 25-28th March 2023. Proceedings published by *Respirology*, 28: 28-109. www.doi.org/10.1111/resp.14459. Research Summary: NA
96. Respiratory Stream	**Nov 2022**	Abstract describing longitudinal change in lung function based on adult Respiratory Stream round 1 and round 2 clinics. Conference proceeding: Holt et al (2023). "Change in Lung Function After Exposure to Smoke from a Mine Fire: A Clinical Follow-up" presented as a poster at the 2023 *Annual Conference of the American Thoracic Society*. Research Summary: NA
97. All	**Nov 2022**	8th Annual Report Report: "Hazelwood Health Study Annual Report 8" available at https://hazelwoodhealthstudy.org.au/study-findings/study-reports
98. Early Life Followup	**Nov 2022**	Manuscript describing results from deidentified extracts of MBS and PBS data for babies. Academic paper: Ziou et al (2023) "Primary and pharmaceutical care usage concurrent associations with a severe smoke episode and low ambient air pollution in early life". Published by *Science of the Total Environment* and freely available at https://doi.org/10.1016/j.scitotenv.2023.163580. Research Summary: https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries
99. Adult Survey	**Feb 2023**	Abstract describing the association between mine fire PM and risk of COVID. Conference proceeding: Lane et al (2023) "Long-term risk of COVID-19 after extreme smoke exposure" presented at the European Respiratory Society (ERS) 2023 International Congress and the Australasian Epidemiological Association (AEA) 2023 Annual Scientific Meeting. Research Summary: NA

100. Adult Survey	**Mar 2023**	Paper describing the association between mine fire smoke exposure and vulnerability to COVID-19 infection, severity and mortality. Academic paper: Lane et al (2023) "Long term effects of extreme smoke exposure on COVID-19: A cohort study" published by *Respirology* and available at https://onlinelibrary.wiley.com/doi/abs/10.1111/resp.14591. A preprint version is also available at https://www.medrxiv.org/content/10.1101/2023.04.12.23288500v1. Research Summary: www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/3268549/2023-May-Long-Term-effect-of-smoke-on-Covid-19-Vulnerability.pdf
101. Early Life Followup	**Mar 2023**	Paper describing the trajectory of FOT results between rounds 1 and 2 clinical data collection Academic paper: Hemstock et al (2023) "Lung function changes in children exposed to mine fire smoke in infancy" under final stages of review with *Respirology*. Research Summary: www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/3268487/May-2023-Lung-function-changes-in-children-exposed-to-mine-fire-smoke-in-infancy.pdf
102. Adult Psychological Impacts	**April 2023**	Paper describing the trajectory of IES-R scores from round 1 (Adult Survey) to round 2 (Adult Psychological Stream Followup Survey) Academic paper: Smith et al (2023) "Sociodemographic circumstances, health, and life experience shape posttraumatic distress trajectories among individuals exposed to smoke during a large-scale coal mine fire." Published in April 2023 by the *J Traumatic Stress*. Freely available at https://doi.org/10.1002/jts.22923 Research Summary: www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0005/3053876/August-2022-Distress-Trajectories.pdf
103. Respiratory Stream	**April 2023**	Paper describing a systematic review of the literature on PM exposure and COVID-19 infections, severity and death. Academic paper: Sheppard et al (2023) "Particulate matter air pollution and COVID-19 infection, severity, and mortality: A systematic review and meta-analysis" published by *Science of The Total Environment*. Freely available at https://onlinelibrary.wiley.com/doi/10.1002/jts.22923 and https://doi.org/10.1016/j.scitotenv.2023.163272 No Research Summary released with this publication as it does not address an HHS research question.
104. Early Life Followup	**April 2023**	Abstract and paper describing allergic sensitisation in smoke exposed children. Academic paper: Ziou et al (2023) "Exposure to air pollution concentrations of various intensities in early life and allergic sensitisation later in childhood" under review with *BMC Pulmonary Medicine*. Conference Proceeding: Ziou et al (2023) "Allergic sensitisation following early life exposure to the Hazelwood mine fire" presented to the Australian Public Health Conference 2023 (26-28 September 2023).

			Research Summary: www.hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0007/3344911/June-2023-Allergies-in-children-seven-years-after-the-mine-fire.pdf
105.	**Adult Respiratory Stream**	**May 2023**	Manuscript describing ventilation heterogeneity using multibreath nitrogen washout (MBW) in adults. Manuscript: McCrabb et al (2023) "Ventilation heterogeneity is increased in adults exposed to coal mine fire-related $PM_{2.5.}$" Freely available on the preprint server medRXiv at www.doi.org/10.1101/2023.06.08.23291105. Under review with *Respirology*. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/3452841/2023-MBW-The-impact-of-coal-mine-fire-smoke-on-lung-ventilation-in-adults-Results-from-the-Respiratory-Stream..pdf
106.	**Adult Survey**	**June 2023**	Abstract and paper describing longitudinal self-reported respiratory symptoms in adults, collected in 2017 and 2022, and their interaction with COVID-19. Abstract: Lane et al (2023) "Respiratory symptoms after coalmine fire and pandemic: a longitudinal analysis of the Hazelwood Health Study adult cohort" accepted for presentation at AEA 2023 and APSR 2023. Manuscript: Lane et al (2023) "Respiratory symptoms after coalmine fire and pandemic: a longitudinal analysis of the Hazelwood Health Study adult cohort". Submitted to *Occupational and Environmental Medicine* and a preprint version is freely available on medRxiv at https://www.medrxiv.org/content/10.1101/2023.08.23.23294510v1. Research Summary: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/3403955/2023-Self-reported-respiratory-health.pdf
107.	**Respiratory Stream**	**Aug 2023**	Paper describing FeNo (airway inflammation) results from Round 2 of the adult Respiratory Stream. Manuscript: Kress et al (2023) "$PM_{2.5}$ from a coal mine fire has little to no long-term impact on eosinophilic airway inflammation" submitted to *Environmental Research Letters*. Research Summary: one combined Research Summary for rows 107 and 108, under review with DH.
108.	**Respiratory Stream**	**Aug 2023**	Paper describing paper lung function at R2 and change in lung function since R1. Manuscript: Holt et al (2023). "Lung function may recover after exposure to smoke from a coal mine fire: cohort study" awaiting DH approval (7/9/2023). Research Summary: one combined Research Summary for rows 107 and 108, under review with DH.
109.	**Early Life Follow Up**	**Sept 2023**	Paper describing vascular health in smoke-exposed young children and 3- and 7-year followup. Manuscript: Hemstock et al (2023). "Increased vascular stiffness in children exposed *in utero* but not children exposed postnatally to emissions from a coalmine fire" in preparation for submission to *Environmental Epidemiology.*

		Research Summary: https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries
110. Community Wellbeing	**Nov 2023**	Paper exploring the unequal mobilities of smoke and people, drawing on concepts of mobility justice and emergency mobilities to reflect on the political dimensions of uneven mobility in times of crisis. Manuscript: Duffy et al (2023) "The social justice issues of smoke im/mobilities." Published in November 2023 by the Australian Geographer and available at https://doi.org/10.1080/00049182.2023.2256595. Research Summary: N/A
111. Adult Psychological Impacts and Community Wellbeing	**Nov 2023**	Paper investigating associations between smoke exposure, psychological distress, sociodemographic circumstances and perceptions of community wellbeing using the CWI. Manuscript: Carroll et al (2023) "Predictors of residents' perspectives on the wellbeing of their community in the aftermath of a prolonged coalmine fire" submitted to DH for approval to release. Research Summary: submitted to DH for approval to release.
112. Community Wellbeing	**Nov 2023**	Paper investigating optimal communication during complex disasters with health impacts. Manuscript: Yell S et al (2023) "Learning lessons in disaster communication: From the Hazelwood mine fire to the COVID-19 pandemic." To be submitted to *Communication Research and Practice*.
113.	**Nov 2023**	Paper investigating whether dietary quality attenuates the adverse effects of mine fire smoke on respiratory health. Manuscript: Govindaraju T et al (2023) "Does diet quality moderate the long-term effects of discrete but extreme PM 2.5 exposure on respiratory symptoms? A study of the Hazelwood coalmine fire." Submitted to DH for approval to release. Research Summary: submitted to DH for approval to release.
114. Hazelinks	**Nov 2023**	Paper investigating the long-term effects of the mine fire smoke on hospital and ambulance use – deidentified data extractions. Manuscript: Lane T et al (2023) "Long-term effects of a coalmine fire on hospital and ambulance use: an interrupted time series study" in final stages of drafting.
115. Cancer	**Nov 2023**	Paper investigating cancer survival to end 2019 using deidentified Victoria-wide data (excluding Melbourne). Manuscript: Lane t et al (2023) "Survival among cancer patients after coalmine fire: Analysis of registry data in regional Victoria, Australia" in final stages of drafting.

Hazelwood Health Study citations

(1-109)

1. Abramson MJ, Blackman J, Carroll M, Dimitriadis C, Del Monaco A, Dennekamp M, et al. Hazelwood Health Study Adult Survey Report: Volume 1 Comparison of Morwell and Sale. 2017. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1636395/hhsadultsurveyvol1_report_v1.1-compressed.pdf.

2. Abramson MJ, Blackman J, Carroll M, Dimitriadis C, Del Monaco A, Dennekamp M, et al. Adults Exposed to Coal Mine Fire Smoke Report More Asthma and Respiratory Symptoms than Those Not Exposed. American Thoracic Society International Conference; May 2018; San Diego, CA2018. Available from: https://www.abstractsonline.com/pp8/#!/4499/presentation/19606.

3. Abramson MJ, Blackman J, Carroll M, Gao CX, Del Monaco A, Brown D, et al. Chronic cough is related to cumulative $PM_{2.5}$ and exposure from a coal mine fire [abstract]. European Respiratory Journal2019. p. PA4455. 10.1183/13993003.congress-2019.PA4455. Available from: https://erj.ersjournals.com/content/54/suppl_63/PA4455.

4. Abramson MJ, Dennekamp M, Straney L, Dimitriadis C, Gao CX, Guo Y. Emergency Presentations and Hospital Admissions Following Exposure to Smoke from a Coal Mine Fire [abstract]. American Thoracic Society International Conference; San Diego, CA2018. Available from: https://www.abstractsonline.com/pp8/#!/4499/presentation/14343.

5. Allen S, Carroll M, Berger E, Maybery D, Campbell T. Hazelwood Health Study Schools Study: Report of Round 2 Qualitative Findings. 2019 31/1/2019. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/1766135/Schools-Study-Round2-Interviews.pdf.

6. Berger E, Carroll M, Maybery D. Children's perspectives on the impact of the Hazelwood mine fire and subsequent smoke event. PsyArXiv Preprints [Internet]. 2018. Available from: https://doi.org/10.31234/osf.io/8mhxf.

7. Berger E, Carroll M, Maybery D, Harrison D. The impact of a disaster on students and staff from a specialist, trauma-informed school in Australia. PsyArXiv Preprints [Internet]. 2018. Available from: https://psyarxiv.com/agdb5/.

8. Berger E, Carroll M, Maybery D, Harrison D. Disaster Impacts on Students and Staff from a Specialist, Trauma-Informed Australian School. Journal of Child & Adolescent Trauma. 2018;11(4):521-30. 10.1007/s40653-018-0228-6. Available from: https://link.springer.com/article/10.1007/s40653-018-0228-6.

9. Berger E, Gao C, Broder J, Campbell T, Maybery D, Carroll M. The impact of a mine fire and smoke event on academic outcomes for primary and secondary school students. Psychol Trauma. 2021. 10.1037/tra0001179.

10. Berger E, Gao CX, Broder J, Campbell TCH, Maybery D, Carroll M. The impact of a mine fire and smoke event on academic outcomes for primary and secondary school students. PsyArXiv. 2020. https://doi.org/10.31234/osf.io/unms5.

11. Berger E, Maybery D, Carroll M. Children's Perspectives on the Impact of the Hazelwood Mine Fire and Subsequent Smoke Event. Child & Youth Care Forum. 2020. 10.1007/s10566-020-09551-8. Available from: https://doi.org/10.1007/s10566-020-09551-8.

12. Betts JM, Dewar EM, Stub DA, Gao CX, Brown DW, Ikin JF, et al. Markers of cardiovascular disease among adults exposed to smoke from the Hazelwood coal mine fire. International Journal of Environmental Research and Public Health. 2021;18(4):1587. https://doi.org/10.3390/ijerph18041587.

13. Betts JM, Gao C, Brown D, Ikin J, Maniam R, Stub D, et al. Factors associated with hypertension and its management among older rural Australians. Australian Journal of Rural Health. 2020;28(4):399-407. https://doi.org/10.1111/ajr.12634. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/ajr.12634.

14. Blackman J, Carroll M, Gao CX, Del Monaco A, Brown MD, Guo Y, et al. Hazelwood Health Study Adult Survey Volume 2: The relationship between Hazelwood mine fire smoke exposure and health outcomes.; 2019. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0008/1636460/hazelwoodhealthstudy-adult-survey-volume-2-report-v1.1.pdf.

15. Broder JC, Gao CX, Abramson MJ, Wolfe R, Dimitriadis C, Ikin J, et al. Long-term impact of exposure to coalmine fire emitted $PM_{2.5}$ on emergency ambulance attendances. Chemosphere. 2022;288:132339. https://doi.org/10.1016/j.chemosphere.2021.132339. Available from: https://www.sciencedirect.com/science/article/pii/S0045653521028113.

16. Broder JC, Gao CX, Campbell TCH, Berger E, Maybery D, McFarlane A, et al. The factors associated with distress following exposure to smoke from an extended coal mine fire. Environmental Pollution. 2020;266:115131. https://doi.org/10.1016/j.envpol.2020.115131. Available from: http://www.sciencedirect.com/science/article/pii/S0269749119373907.

17. Carroll M, Campbell T, Gao CX, Smith C, Maybery D, Berger E, et al. Hazelwood Health Study Technical Report 2019-2020 Mental Health and Wellbeing Follow-up Survey. A follow-up to the 2016-2017 Adult Survey investigating the ongoing psychological health of adults who lived in Morwell during the 2014 Hazelwood mine fire.; 2020. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0011/2424863/Mental_Health_Follow-up_Technical_Report-1.0.pdf.

18. Carroll M, Campbell TCH, Smith CL, Gao CX, Maybery D, Berger E, et al. An exploration of the trajectory of psychological distress associated with exposure to smoke during the 2014 Hazelwood coal mine fire. PsyArXiv [Internet]. 2021. Available from: https://psyarxiv.com/tz5c4/.

19. Carroll M, Campbell TCH, Smith CL, Gao CX, Maybery D, Berger E, et al. An exploration of the trajectory of psychological distress associated with exposure to smoke during the 2014 Hazelwood coal mine fire. International Journal of Hygiene and Environmental Health. 2022;241:113946. https://doi.org/10.1016/j.ijheh.2022.113946. Available from: https://www.sciencedirect.com/science/article/pii/S1438463922000293.

20. Carroll M, Gao CX, Campbell TCH, Smith CL, Dimitriadis C, Berger E, et al. Impacts of coal mine fire-related $PM_{2.5}$ on the utilisation of ambulance and hospital services for mental health conditions. PsyArXiv Preprints [Internet]. 2021. Available from: https://doi.org/10.31234/osf.io/hgv7t.

21. Carroll M, Gao CX, Campbell TCH, Smith CL, Dimitriadis C, Berger E, et al. Impacts of coal mine fire-related $PM_{2.5}$ on the utilisation of ambulance and hospital services for mental health conditions. Atmospheric Pollution Research. 2022;13(5):101415. https://doi.org/10.1016/j.apr.2022.101415. Available from: https://www.sciencedirect.com/science/article/pii/S1309104222001015.

22. Carroll M, Maybery D, Berger E, Lee S, Gao CX, Wolfe R. Hazelwood Health Study Psychological Impacts Stream: Analysis of the key quantitative outcome variables from the first year of Schools Study data collection. 2017. Available from:

https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/1636476/schools-study-analysis-of-round-1-key-quantitative-data-v1.0.pdf.

23. Carroll M, Walker J. Beyond vulnerability: Older people as active participants in disaster responses . Presented at the Perth, Australia. 50th Australian Association of Gerontology (AAG) Conference; November 2017; Perth, Australia2017. Available from: https://www.aag.asn.au/documents/item/2003.

24. Chappell K, Melody S, Wheeler A, Dalton M, O'Sullivan T, Williamson GJ, et al. The Latrobe Early Life Follow-up (ELF) Cohort Study Volume 5. 2020. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/2424871/ELF-Report-Vol-5_Version1.0.pdf.

25. Dennekamp M, Straney L, Dimitriadis C, Gao CX, Guo Y, Abramson MJ. Hazelwood Heath Study Hazelinks Emergency presentations and hospital admissions analysis (First Data Extraction) V 1.2. 2017. Available from: https://hazelwoodhealthstudy.org.au/study-findings/study-reports.

26. Dimitriadis C, Gao CX, Ikin JF, Wolfe R, Gabbe BJ, Sim MR, et al. Exposure to mine fire related particulate matter and mortality: A time series analysis from the Hazelwood Health Study. Chemosphere. 2021;285:131351. https://doi.org/10.1016/j.chemosphere.2021.131351. Available from: https://www.sciencedirect.com/science/article/pii/S0045653521018233.

27. Duffy M, Whyte S. The Latrobe Valley: The politics of loss and hope in a region of transition. Australasian Journal of Regional Studies. 2017;23(3):421-46. Available from: https://www.anzrsai.org/assets/Uploads/PublicationChapter/AJRS-23.3-pages-421-to-446.pdf.

28. Duffy M, Yell S, Walker L, Morgan D, Carroll M. The social justice issues of smoke im/mobilities. Australian Geographer. 2023;54(4):573-87. 10.1080/00049182.2023.2256595. Available from: https://doi.org/10.1080/00049182.2023.2256595.

29. Emmerson K, Reisen F, Luhar A, Williamson G, Cope M. Air quality modelling of smoke exposure from the Hazelwood mine fire2016 1 February 2021. Available from: https://hazelwoodhealthstudy.org.au/study-findings/study-reports.

30. Gao CX, Broder JC, Brilleman S, Berger E, Ikin J, Smith CL, et al. Evaluating the impact of Hazelwood mine fire event on students' educational development with Bayesian interrupted time-series hierarchical meta-regression. medRxiv. 2021. 10.1101/2021.03.28.21254516. Available from: https://www.medrxiv.org/content/medrxiv/early/2021/04/04/2021.03.28.21254516.full.pdf.

31. Gao CX, Broder JC, Brilleman S, Campbell TCH, Berger E, Ikin J, et al. Evaluating the impact of Hazelwood mine fire event on students' educational development with Bayesian interrupted time-series hierarchical meta-regression. PLoS One. 2023;18(3):e0281655. 10.1371/journal.pone.0281655.

32. Gao CX, Dimitriadis C, Ikin J, Dipnall JF, Wolfe R, Sim MR, et al. Impact of exposure to mine fire emitted $PM_{2.5}$ on ambulance attendances: A time series analysis from the Hazelwood Health Study. Environmental Research. 2020;196:110402. https://doi.org/10.1016/j.envres.2020.110402. Available from: http://www.sciencedirect.com/science/article/pii/S0013935120312998.

33. Gao CX, Menssink J, Campbell TCH, Smith CL, Ikin JF, Lane T, et al. Somatic symptoms, psychological distress and trauma after disasters: lessons from the 2014 Hazelwood mine fire and 2019–20 Black Summer bushfires. BMC public health. 2023;23(1):1573. 10.1186/s12889-023-16501-1. Available from: https://doi.org/10.1186/s12889-023-16501-1.

34. Guo Y, Dimitriadis C, Gao CX, Wolfe R, Ikin JF, Gabbe B, et al. Hazelinks Mortality Report Time series analyses for the period July 2009 to June 2015. Version 1.2. 2020. Available from:

https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/2370046/Hazelinks-Mortality-Data-Technical-Report-Version-1.2-1.pdf.

35. Guo Y, Gao CX, Dennekamp M, Dimitriadis C, Straney L, Ikin J, et al. The association of coal mine fire smoke with hospital emergency presentations and admissions: Time series analysis of Hazelwood Health Study. Chemosphere. 2020;253:126667. https://doi.org/10.1016/j.chemosphere.2020.126667. Available from: http://www.sciencedirect.com/science/article/pii/S0045653520308602.

36. Guo Y, Gao CX, Dipnall J, Wolfe R, Blackman J, Dimitriadis C, et al. Hazelwood Health Study Hazelinks Ambulance Victoria Data: Time Series Analyses (First Data Extraction) version 1.1. 2017.

37. Hazelwood Health Study. Hazelwood Health Study Recruitment Report 2. 2017. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1636276/hhs-2ndrecruitmentreport_v1.1.pdf.

38. Hemstock EJ, Foong RE, Hall GL, Wheeler AJ, Dharmage SC, Dalton M, et al. No association between in utero exposure to emissions from a coalmine fire and post-natal lung function. BMC Pulmonary Medicine. 2023;23(1):120. 10.1186/s12890-023-02414-7. Available from: https://doi.org/10.1186/s12890-023-02414-7.

39. Hemstock EJ, Shao J, Zhao B, Hall GL, Wheeler AJ, Dharmage SC, et al. Associations between respiratory and cardiovascular function in early childhood. Respirology. 2021;26(11):1060-6. 10.1111/resp.14117. Available from: https://doi.org/10.1111/resp.14117

40. Holt N, Gao C, Borg B, Nilsen K, Brown D, Broder J, et al. Altered lung mechanics after coal mine fire smoke exposure in adults [abstract]. European Respiratory Journal. 2020;56(Suppl 64):3146. 10.1183/13993003.congress-2020.3146.

41. Holt NR, Gao CX, Borg BM, Brown D, Broder JC, Ikin J, et al. Long term impact of coal mine fire smoke on lung mechanics in exposed adults. medRxiv. 2020. 10.1101/2020.10.14.20213009. Available from: https://www.medrxiv.org/content/medrxiv/early/2020/10/20/2020.10.14.20213009.full.pdf.

42. Holt NR, Gao CX, Borg BM, Brown D, Broder JC, Ikin J, et al. Long-term impact of coal mine fire smoke on lung mechanics in exposed adults. Respirology. 2021;26:861-8. https://doi.org/10.1111/resp.14102.

43. Ikin J, Carroll M, Walker J, Borg B, Brown D, Cope M, et al. Cohort Profile: The Hazelwood Health Study Adult Cohort. International Journal of Epidemiology. 2020;49(6):1777-8. 10.1093/ije/dyaa083. Available from: https://doi.org/10.1093/ije/dyaa083.

44. Johnson AL, Dipnall J, Dennekamp M, Williamson G, Gao CX, Carroll M, et al. Brown Coal Mine Fire-Related Fine Particulate Matter and Medical Service Utilisation in Australia: A Time Series Analysis. International Society of Exposure Science and International Society for Environmental Epidemiology 2018 Joint Annual Meeting; 26–30 August 2018; Ottawa, Canada2018. Available from: https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.O02.04.19.

45. Johnson AL, Dipnall J, Dennekamp M, Williamson G, Gao CX, Carroll M, et al. Fine Particulate Matter and Medications Dispensed during and after a Brown Coal Mine Fire: A Time Series Analysis [abstract]. International Society of Exposure Science and International Society for Environmental Epidemiology 2018 Joint Annual Meeting; 26–30 August 2018; Ottawa, Canada2018. Available from: https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.P02.1550.

46. Johnson AL, Dipnall JF, Dennekamp M, Williamson GJ, Gao CX, Carroll MTC, et al. Fine particulate matter exposure and medication dispensing during and after a coal mine fire: A time series analysis

from the Hazelwood Health Study. Environmental Pollution. 2019;246:1027-35. https://doi.org/10.1016/j.envpol.2018.12.085. Available from: http://www.sciencedirect.com/science/article/pii/S0269749118335279.

47. Johnson AL, Gao CX, Dennekamp M, Williamson GJ, Brown D, Carroll MTC, et al. Associations between Respiratory Health Outcomes and Coal Mine Fire $PM_{2.5}$ Smoke Exposure: A Cross-Sectional Study. International Journal of Environmental Research and Public Health. 2019;16(21):4262. doi:10.3390/ijerph16214262. Available from: https://www.mdpi.com/1660-4601/16/21/4262.

48. Johnson AL, Gao CX, Dennekamp M, Williamson GJ, Carroll MTC, Dimitriadis C, et al. Coal-mine fire-related fine particulate matter and medical-service utilization in Australia: A time-series analysis from the Hazelwood Health Study. International Journal of Epidemiology. 2020;49(1):80-93. https://doi.org/10.1093/ije/dyz219. Available from: https://academic.oup.com/ije/article-abstract/49/1/80/5607294?redirectedFrom=fulltext.

49. Johnson AL, Guo Y, Dipnall J, Blackman J, Dimitriadis C, Abramson MJ. Hazelwood Health Study Hazelinks Medicare Benefits Schedule and Pharmaceutical Benefits Scheme data: Time Series Analyses. 2018. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0010/2324908/Hazelinks-MBS-PBS-Technical-Report-Version-2.0.pdf.

50. Jones R, Lee S, Maybery D, McFarlane A. Experiences of a prolonged coal-mine fire. Disaster Prev Manag. 2018;27(5):534-45. 10.1108/Dpm-05-2018-0145. Available from: https://research.monash.edu/en/publications/experiences-of-a-prolonged-coal-mine-fire.

51. Lane T, Carroll M, Borg B, Mccaffrey T, Gao C, Smith C, et al. Long-term risk of COVID-19 after extreme smoke exposure. European Respiratory Journal. 2023;62(suppl 67):PA3810. 10.1183/13993003.congress-2023.PA3810.

52. Lane TJ, Carroll M, Borg BM, McCaffrey TA, Smith CL, Gao CX, et al. Long-term effects of extreme smoke exposure on COVID-19: A cohort study. Respirology. 2023. https://doi.org/10.1111/resp.14591. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/resp.14591.

53. Lane TJ, Carroll M, Borg BM, McCaffrey TA, Smith CL, Gao CX, et al. Long-term effects of extreme smoke exposure on COVID-19: A cohort study. medRxiv. 2023:2023.04.12.23288500. 10.1101/2023.04.12.23288500. Available from: https://www.medrxiv.org/content/medrxiv/early/2023/04/15/2023.04.12.23288500.full.pdf.

54. Lee WK, Smith CL, Gao CX, Borg BM, Nilsen K, Brown D, et al. Are e-cigarette use and vaping associated with increased respiratory symptoms and poorer lung function in a population exposed to smoke from a coal mine fire? Respirology. 2021;26(10):974-81. https://doi.org/10.1111/resp.14113.

55. Luhar A, Emmerson K, Reisen F, Williamson G, Cope M. Modelling smoke distribution in the vicinity of a large and prolonged fire from an open-cut coal mine. Atmospheric Environment. 2020:117471. https://doi.org/10.1016/j.atmosenv.2020.117471. Available from: http://www.sciencedirect.com/science/article/pii/S1352231020302089.

56. Maybery D, Berger E, Dipnall JF, Campbell TCH, Carroll M. Posttraumatic Stress Among School Students Following the 2014 Hazelwood Mine Fire. Journal of Aggression, Maltreatment & Trauma. 2023:1-17. 10.1080/10926771.2023.2228240. Available from: https://doi.org/10.1080/10926771.2023.2228240.

57. Maybery D, Carroll M, Berger E, Dipnall J, Lee S. The psychological impact and experiences of children following the Hazelwood mine fire and subsequent smoke event. PsyArXiv [Internet]. 2019. Available from: https://psyarxiv.com/rw657.

58. Maybery D, Jones R, Carroll M, Dipnall J, Berger E, Campbell TCH, et al. Psychological outcomes following the Hazelwood mine fire: A mixed methods study. PsyArXiv [Internet]. 2019. Available from: https://psyarxiv.com/euj96/.

59. Maybery D, Jones R, Dipnall JF, Berger E, Campbell T, McFarlane A, et al. A mixed-methods study of psychological distress following an environmental catastrophe: The case of the Hazelwood open-cut coalmine fire in Australia. Anxiety, Stress, & Coping. 2020;33(2):216-30. 10.1080/10615806.2019.1695523. Available from: https://doi.org/10.1080/10615806.2019.1695523.

60. Melody SM, Dalton M, Dennekamp M, Wheeler A, Dharmage S, Wills K, et al. Hazelwood Health Study Latrobe Early Life Follow-up (ELF) Cohort Study Volume 1 Report: Description of the cohort and preliminary assessment of possible associations between mine fire emissions and parent-reported perinatal outcomes. Version 1.2. 2017. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/1636452/elf-vol-1_-cohortdesciption_parentreportedoutcomes-v1.2.pdf.

61. Melody SM, Dalton M, Wills K, Ford J, O'Sullivan T, Williamson G, et al. Hazelwood Health Study Latrobe Early Life Follow-up (ELF) Cohort Study Volume 4: An extended analysis of possible associations between mine fire emissions and perinatal outcomes. 2019. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/2052517/Latrobe-ELF-tech-report-volume-4_v1.0.pdf.

62. Melody SM, Ford J, Wills K, Venn A, Johnston FH. Maternal exposure to fine particulate matter from a coal mine fire and birth outcomes in Victoria, Australia. Environment International. 2019;127:233-42. 10.1016/j.envint.2019.03.028. Available from: https://www.sciencedirect.com/science/article/pii/S0160412018331878?via%3Dihub.

63. Melody SM, Ford JB, Wills K, Venn A, Johnston FH. Maternal exposure to fine particulate matter from a large coal mine fire is associated with gestational diabetes mellitus: A prospective cohort study. Environmental Research. 2020;183:108956. https://doi.org/10.1016/j.envres.2019.108956. Available from: http://www.sciencedirect.com/science/article/pii/S0013935119307534.

64. Melody SM, Johnston FH. Coal mine fires and human health: What do we know? International Journal of Coal Geology. 2015;152:1-14. 10.1016/j.coal.2015.11.001. Available from: https://www.sciencedirect.com/science/article/pii/S0166516215300707?via%3Dihub.

65. Melody SM, Wheeler AJ, Dalton M, Williamson GJ, Negishi K, Willis G, et al. Cohort Profile: The Hazelwood Health Study Latrobe Early Life Follow-Up (ELF) Study. International Journal of Epidemiology. 2020;49(6):1779-80. 10.1093/ije/dyaa136. Available from: https://doi.org/10.1093/ije/dyaa136.

66. Mundisugih J, Gao C, Ikin J, Abramson M, Brown D, Biswas S, et al. Vascular responses among adults exposed to smoke from the Hazelwood coal mine fire. Vascular Health and Risk Management. 2022;18:253-65. 10.2147/VHRM.S339439. Available from: https://doi.org/10.2147/VHRM.S339439.

67. O'Donohue K, Berger E, McLean L, Carroll M. Psychological outcomes for young adults after disastrous events: A mixed-methods scoping review. Social Science and Medicine. 2021;276:113851. 10.1016/j.socscimed.2021.113851. Available from: https://pubmed.ncbi.nlm.nih.gov/33812159/.

68. O'Donohue KA, Berger E, McLean L, Gao CX, Broder JC, Abramson MJ, et al. The psychological impacts of a smoke event on young adults compared to other aged adults in Victoria, Australia. International

Journal of Disaster Risk Reduction. 2022;70:102727. https://doi.org/10.1016/j.ijdrr.2021.102727. Available from: https://www.sciencedirect.com/science/article/pii/S2212420921006889.

69. Owen AJ, Abramson MJ, Ikin JF, McCaffrey TA, Pomeroy S, Borg BM, et al. Recommended Intake of Key Food Groups and Cardiovascular Risk Factors in Australian Older, Rural-Dwelling Adults. Nutrients. 2020;12(3):860. doi:10.3390/nu12030860. Available from: https://www.mdpi.com/2072-6643/12/3/860.

70. Prasad S, Gao C, Borg B, Broder J, Brown D, Ikin J, et al. Chronic Obstructive Pulmonary Disease in adults exposed to fine particles from a coal mine fire. medRxiv. 2020. 10.1101/2020.10.14.20213033. Available from: https://www.medrxiv.org/content/medrxiv/early/2020/10/20/2020.10.14.20213033.full.pdf.

71. Prasad S, Gao CX, Borg B, Broder J, Brown D, Ikin JF, et al. Chronic Obstructive Pulmonary Disease in Adults Exposed to Fine Particles from a Coal Mine Fire. Annals of the American Thoracic Society. 2022;19(2):186-95. 10.1513/AnnalsATS.202012-1544OC. Available from: https://doi.org/10.1513/AnnalsATS.202012-1544OC.

72. Prasad SR, Borg B, Gao C, Broder J, Brown D, Ikin J, et al. Chronic Obstructive Pulmonary Disease Is Associated with Exposure to Fine Particles from a Coal Mine Fire [abstract]. American Journal of Respiratory and Critical Care Medicine. 2020;201:A7835. 10.1164/ajrccm-conference.2020.201.1_MeetingAbstracts.A7835. Available from: https://www.atsjournals.org/doi/abs/10.1164/ajrccm-conference.2020.201.1_MeetingAbstracts.A7835.

73. Reisen F, Gillett R, Choi J, Fisher G, Torre P. Characteristics of an open-cut coal mine fire pollution event. Atmospheric Environment. 2017;151:140-51. 10.1016/j.atmosenv.2016.12.015. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1352231016309748.

74. Samuel R, Carroll MTC, Ikin JF, Gao CX, Del Monaco A, McFarlane A, et al. Associations between self-reported respiratory symptoms and non-specific psychological distress following exposure to a prolonged landscape fire. Stress and Health. 2022;38(2). https://doi.org/10.1002/smi.3097. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/smi.3097.

75. Samuel R, Gao CX, Broder J, Brown D, Del Monaco A, Ikin J, et al. Associations between self-reported respiratory symptoms and non-specific psychological distress following exposure to a landscape fire. Poster presented online at the Annual Scientific Meeting of the Thoracic Society of Australia & New Zealand Victorian Branch; Melbourne2020.

76. Shao J, Wheeler A, R. Zosky G, Johnston F. Long-term impacts of prenatal and infant exposure to fine particulate matter on wheezing and asthma: A systematic review and meta-analysis. Environmental Epidemiology. 2019;3:e042. 10.1097/EE9.0000000000000042. Available from: https://journals.lww.com/environepidem/Fulltext/2019/04000/Long_term_impacts_of_prenatal_and_infant_exposure.1.aspx.

77. Shao J, Zosky G, Hall G, Foong R, Wheeler AJ, Dalton M, et al., editors. Exposure to Smoke from a Coal Mine Fire during Infancy and Lung Function Three Years after the Event [abstract]. International Society for Environmental Epidemiology Annual Conference; 2018; Ottawa, Canada. https://ehp.niehs.nih.gov/doi/10.1289/isesisee.2018.P02.1800. Available from: https://ehp.niehs.nih.gov/action/doSearch?AllField=jingyi+shao.

78. Shao J, Zosky G, Hall G, Wheeler A, Dalton M, Dharmage S, et al. An assessment of early life exposure to coalmine fire smoke and children's lung health (abstract TOL 003). Respirology. 2018;23(S1):56. https://doi.org/10.1111/resp.13267.

79. Shao J, Zosky GR, Hall GL, Foong RE, Wheeler A, Dharmage S, et al. Hazelwood Heatlh Study Latrobe Early Life Follow-up (ELF) Cohort Study Volume 2: Investigation of possible associations between exposure to mine fire emissions and indicators of lung function measured three years after the fire 2018 [Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/2052516/ELFVol-2-Lung-Function-Testing-v1.1.pdf.

80. Shao J, Zosky GR, Hall GL, Wheeler AJ, Dharmage S, Foong R, et al. Ambient Nitrogen Dioxide Exposure During Infancy Influences Respiratory Mechanics in Preschool Years [Abstract]. In the American Thoracic Society International Conference, Dallas, US, 17-22 May 2019. American Journal of Respiratory and Critical Care Medicine. 2019;199:A7058. 10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A7058. Available from: https://www.atsjournals.org/doi/abs/10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A7058.

81. Shao J, Zosky GR, Hall GL, Wheeler AJ, Dharmage S, Melody S, et al. Early life exposure to coal mine fire smoke emissions and altered lung function in young children. Respirology. 2020;25(2):198-205. 10.1111/resp.13617. Available from: https://onlinelibrary.wiley.com/doi/10.1111/resp.13617.

82. Shao J, Zosky GR, Wheeler AJ, Dharmage S, Dalton M, Williamson GJ, et al. Exposure to air pollution during the first 1000 days of life and subsequent health service and medication usage in children. Environmental Pollution. 2020;256:113340. 10.1016/j.envpol.2019.113340. Available from: https://www.ncbi.nlm.nih.gov/pubmed/31662257.

83. Sheppard N, Carroll M, Gao C, Lane T. Particulate matter air pollution and COVID-19 infection, severity, and mortality: A systematic review and meta-analysis. Science of The Total Environment. 2023:163272. https://doi.org/10.1016/j.scitotenv.2023.163272. Available from: https://www.sciencedirect.com/science/article/pii/S0048969723018910.

84. Sim MR, Dimitriadis C, Gao CX, Del Monaco A. Hazelwood Health Study Hazelinks Cancer incidence analysis (First data extraction). 2017. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0003/1636482/20170919-cancer-analysis-data-extraction-technical-report-v1.0-1.pdf.

85. Smith CL, Campbell TCH, Gao CX, Lane TJ, Maybery D, Berger E, et al. Sociodemographic circumstances, health, and life experience shape posttraumatic distress trajectories among individuals exposed to smoke during a large-scale coal mine fire. Journal of Traumatic Stress. 2023;36(2):465-73. https://doi.org/10.1002/jts.22923. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/jts.22923.

86. Smith CL, Gao CX, Xu R, Ikin JF, Dimitriadis C, Carroll MTC, et al. Long-term impact of the 2014 Hazelwood coal mine fire on emergency department presentations in Australia. Environmental Research. 2023;223:115440. https://doi.org/10.1016/j.envres.2023.115440. Available from: https://www.sciencedirect.com/science/article/pii/S0013935123002323.

87. Taylor S, Borg B, Gao C, Brown D, Hoy R, Makar A, et al. Is asthma associated with exposure to smoke from a coal mine fire? bioRxiv [Internet]. 2019:[631317 p.]. Available from: http://biorxiv.org/content/early/2019/05/10/631317.abstract.

88. Taylor S, Borg B, Gao C, Brown D, Hoy R, Makar A, et al. The impact of the Hazelwood coal mine fire smoke exposure on asthma. Journal of Asthma. 2022;59(2):213-22. 10.1080/02770903.2020.1847931. Available from: https://doi.org/10.1080/02770903.2020.1847931.

89. Walker J, editor The impact of the Hazelwood mine fire in Australia on older people: review of policy-driven decisions made at the time [abstract]. Aging and Society : Seventh Interdisciplinary

Conference; 2017 3-5 November 2017; Berkeley, USA. Available from: https://agingandsocialchange.com/assets/downloads/aging/J17FinalProgam.pdf.

90. Walker J, Carroll M, editors. Communications in future disaster events: best practice policy for older people [abstract]. Australia and New Zealand Disaster and Emergency Management Conference; 2017 22-23 May 2017; Gold Coast, Qld, Australia.

91. Walker J, Carroll M, Chisolm M. Hazelwood Health Study policy review of the impact of the Hazelwood mine fire on older people: Final Report. 2016. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0004/1636384/policy-review-older-people-v1.0-website.pdf.

92. Walker J, Carroll M, Chisolm M. Policy Brief - Policy review of the impact of the Hazelwood mine fire on older people: Final Report. 2017. Available from: https://hazelwoodhealthstudy.org.au/study-findings/fact-sheets-and-summaries.

93. Willis G, Chappell K, Williams S, Melody S, Wheeler A, Dalton M, et al. The Latrobe Early Life Follow-up (ELF) Cohort Study Volume 6. The impact of exposure to coal mine fire smoke in early life on parent-reported indicators of childhood atopic and respiratory illness. Version 1.0.; 2019. Available from: https://hazelwoodhealthstudy.org.au/study-findings/study-reports.

94. Willis GA, Chappell K, Williams S, Melody SM, Wheeler A, Dalton M, et al. Respiratory and atopic conditions in children two to four years after the 2014 Hazelwood coalmine fire. Medical Journal of Australia. 2020;213(6):269-75. https://doi.org/10.5694/mja2.50719. Available from: https://onlinelibrary.wiley.com/doi/abs/10.5694/mja2.50719.

95. Xu R, Gao CX, Dimitriadis C, Smith CL, Carroll MTC, Ikin JF, et al. Long-term impacts of coal mine fire-emitted $PM_{2.5}$ on hospitalisation: a longitudinal analysis of the Hazelwood Health Study. International Journal of Epidemiology. 2021;51(1):179-90. 10.1093/ije/dyab249. Available from: https://academic.oup.com/ije/article-abstract/51/1/179/6453863.

96. Yell S, Duffy M. Community empowerment and trust: social media use during the Hazelwood mine fire. Australian Journal of Emergency Management. 2018;33(2):66-70. 10.3316/informit.589223208133521. Available from: https://search.informit.org/doi/10.3316/informit.589223208133521.

97. Yell S, Duffy M, Morrisey B, Walker L, editors. Communities, authority and trust in the Fifth Estate: Social media use during the Hazelwood coalmine fire [abstract]. Australia and New Zealand Communication Association Conference on Creating Space in the Fifth Estate; 2016 6-8 July 2016; Newcastle, NSW, Australia.

98. Yell S, Duffy M, Whyte S, Walker L, Carroll M, Walker J. Hazelwood Health Study Community Wellbeing Stream Report Volume 1: Community perceptions of the impact of the smoke event on community wellbeing and of the effectiveness of communication during and after the smoke event. 2019. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0018/2052540/CW-Report-Volume-1_v2.0.pdf.

99. Yell S, Duffy M, Whyte S, Walker L, Carroll M, Walker J. Hazelwood Health Study Community Wellbeing Stream Report Volume 2: Community perceptions of the effectiveness of community rebuilding activities. 2019. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0009/2059236/CW-Report-Volume-2_version-1.0.pdf.

100. Yu P, Guo Y, Gao CX, Dimitriadis C, Ikin JF, Del Monaco A, et al. Impacts of High Concentration, Medium Duration Coal Mine Fire Related PM_{2.5} on Cancer Incidence: 5-Year Follow-Up of the Hazelwood Health Study. Environmental Health Insights. 2021;15(1). Available from: https://doi.org/10.1177/11786302211059722.

101. Zhao B, Johnston FH, Dalton M, Negishi K. Feasibility and Normal Ranges of Arterial Intima-Media Thickness and Stiffness in 2-Year-Old Children: A Pilot Study. Pediatric Cardiology. 2019;40(5):914-20. 10.1007/s00246-019-02088-1. Available from: https://link.springer.com/article/10.1007/s00246-019-02088-1.

102. Zhao B, Johnston FH, Dalton M, Williamson G, O'Sullivan T, Negishi K. Smoking during pregnancy significantly increases the risk of early atherosclerosis: a study from coalmine smoke exposure [abstract]. European Society of Cardiology Congress; 25-29 August 2018; Munich, Germany2018. Available from: https://esc365.escardio.org/Congress/ESC-Congress-2018/Best-Posters-6-Best-Posters-in-preventive-cardiology/176295-smoking-during-pregnancy-significantly-increases-the-risk-of-early-atherosclerosis-a-study-from-coalmine-smoke-exposure#abstract.

103. Zhao B, Johnston FH, Negishi K. Abstract 13237: Feasibility and Normal Ranges of Arterial Intima-Media Thickness and Stiffness in 2-Year-Old Children. Circulation. 2018;138(Suppl_1):A13237-A. 10.1161/circ.138.suppl_1.13237. Available from: https://www.ahajournals.org/doi/abs/10.1161/circ.138.suppl_1.13237.

104. Zhao B, Johnston FH, O'Sullivan T, Williamson GJ, Melody S, Dalton M, et al. Early life exposure to coal mine fire and tobacco smoke affect subclinical vascular function. Archives of Disease in Childhood. 2019;105(6):539-44. 10.1136/archdischild-2019-317528. Available from: https://adc.bmj.com/content/archdischild/early/2019/12/20/archdischild-2019-317528.full.pdf.

105. Zhao B, Negishi K, Williamson G, Melody SM, O'Sullivan T, Dalton M, et al. Hazelwood Health Study Latrobe Early Life Follow-up (ELF) Cohort Study Volume 3: Investigation of possible associations between coal mine fire emissions and vascular outcomes in the ELF cohort three years after the fire. 2018. Available from: https://hazelwoodhealthstudy.org.au/__data/assets/pdf_file/0006/2150547/ELF-Cohort-Study_Volume-3-CV-Report_v1.1.pdf.

106. Ziou M, Gao CX, Wheeler AJ, Zosky GR, Stephens N, Knibbs LD, et al. Contrasting Health Outcomes following a Severe Smoke Episode and Ambient Air Pollution in Early Life: Findings from an Australian Data Linkage Cohort Study of Hospital Utilization. Environmental health perspectives. 2023;131(11):117005. doi:10.1289/EHP12238. Available from: https://ehp.niehs.nih.gov/doi/abs/10.1289/EHP12238.

107. Ziou M, Gao CX, Wheeler AJ, Zosky GR, Stephens N, Knibbs LD, et al. Primary and pharmaceutical care usage concurrent associations with a severe smoke episode and low ambient air pollution in early life. Science of The Total Environment. 2023;883:163580. https://doi.org/10.1016/j.scitotenv.2023.163580. Available from: https://www.sciencedirect.com/science/article/pii/S004896972302199X.

108. Ziou M, Gao XC, Wheeler A, Zosky G, Stephens N, Knibbs L, et al., editors. Early life exposure to coal smoke and hospital visitation: findings from a data linkage cohort study. International Society for Environmental Epidemiology Annual Meeting; 2022; Athens, Greece: Environmental Health Perspectives. Available from: https://ehp.niehs.nih.gov/doi/abs/10.1289/isee.2022.P-0441.

109. Ziou M, Tham R, Wheeler AJ, Zosky GR, Stephens N, Johnston FH. Outdoor particulate matter exposure and upper respiratory tract infections in children and adolescents: A systematic review and meta-analysis. Environmental Research. 2022;210:112969.

https://doi.org/10.1016/j.envres.2022.112969. Available from: https://www.sciencedirect.com/science/article/pii/S0013935122002961.

Hazelwood HEALTH STUDY

Research Summary

General practitioner visits and medications prescribed for infants following their exposure to mine fire smoke

January 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air quality incidents in Victoria's history. It caused considerable community concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire. The HHS involves multiple research streams targeting different health outcomes and different vulnerable groups.

The **Latrobe Early Life Follow up (ELF) Study** is the part of the Hazelwood Health Study that follows the health and growth of children who were younger than two years old when the fire occurred. This includes children whose mothers were pregnant with them at the time.

Analysis aims

We aimed to find out if exposure to smoke from the mine fire, either during pregnancy or during the first two years of childhood, was associated with increased general practitioner (GP) visits and dispensing of prescribed medications over a two-year period following the fire

What we did

After getting ethical approval for this research, we obtained anonymous birth records for all babies born in the Latrobe Valley before, during and after the fire (born 1st March 2012 to 31st December 2014), who had been linked by the Centre for Victorian Data Linkage with Medicare Benefits Schedule (MBS) data on visits to GPs and Pharmaceutical Benefits Scheme (PBS) data on dispensed prescription medications. We used air pollution data provided by CSIRO and the residential address at the time of birth to estimate how much mine fire smoke the child or their pregnant mother was exposed to during the fire period.

We looked to see if different amounts of mine fire smoke exposure were associated with higher numbers of GP visits for any cause, or filling of prescriptions for medicines used to treat infections, eczema or respiratory symptoms.
For children whose mothers were exposed to smoke during pregnancy, we evaluated these outcomes in their first two years of life. For children who were exposed to smoke during infancy, we evaluated them in the two-year period following the fire.

In our analysis we considered other factors that can affect health of children, such as infant sex, the mother's smoking status during pregnancy, and usual background levels of air pollution, to distinguish the specific influence of the smoke from the mine fire.

Hazelwood HEALTH STUDY

What we found

We found that children whose mothers were exposed to higher levels of mine fire smoke during pregnancy were more likely to have prednisolone, or similar steroid medications, dispensed in the first two years of life. These medications are mainly used to treat croup and asthma symptoms.

We found that children exposed to the mine fire smoke during their first two years of life were more likely to have prescriptions for antibiotics dispensed in the two years following the fire, and prescriptions for skin creams for eczema in the second year after the fire. They were also more likely to visit a GP, particularly in the first year after the fire.

A detailed paper describing the findings from this analysis can be requested from the study team by emailing contact@hazelwoodhealthstudy.org.au

Considerations

We calculated exposure based on the mother's home address. This means we may not have captured changes in smoke exposure that resulted from each family's movements within and outside of the Latrobe Valley during the fire. Also, this study could not determine contributing reasons for increases in GP visits and prescriptions dispensed following the fire. For example, the findings could reflect a heightened level of worry among parents in the two years after the fire leading them to seek care more frequently for their children for minor symptoms, or there could randomly have been more influenza or gastroenteritis viruses circulating in childcare centres around the areas where there was the most smoke. Finally, only prescribed and subsidised medications were included in the PBS data, so we could not account for some asthma puffers and weak steroid skin creams bought over-the-counter.

Meet the team

Fay Johnston
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Shannon Melody
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Where to from here?

These findings will be shared with relevant organisations and the scientific community to ensure they are used to shape services for the future health of the Latrobe Valley. Additionally, findings will help guide responses to severe smoke events in the future. We will also assess if exposure to smoke from the coal mine fire was associated with increases in use of health services among these children later in childhood, to see if the associations persist.

The HHS is led by Monash University with collaborators from Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Victorian Department of Health.

Hazelwood HEALTH STUDY

Research Summary

Long-term effects of extreme smoke exposure on vulnerability to COVID-19

May 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognized as one of the most significant air quality incidents in Victoria's history, with the concentration of smoke contaminants reaching high levels. The smoke event caused considerable concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire.

More recently, the COVID-19 pandemic has impacted the Latrobe City region with more than 32,000 confirmed cases. International researchers have shown a link between exposure to air pollution, such as smoke and traffic exhaust, and the risk of being infected with COVID-19. One theory is that air pollution increases the number of receptors in the body that the COVID-19 virus uses to bind to and infect cells.

Meet the team

Tyler Lane
Matthew Carroll
Brigitte Borg
Tracey McCaffrey
Catherine Smith
Caroline Gao
David Brown
David Poland
Shantelle Allgood
Jillian Ikin
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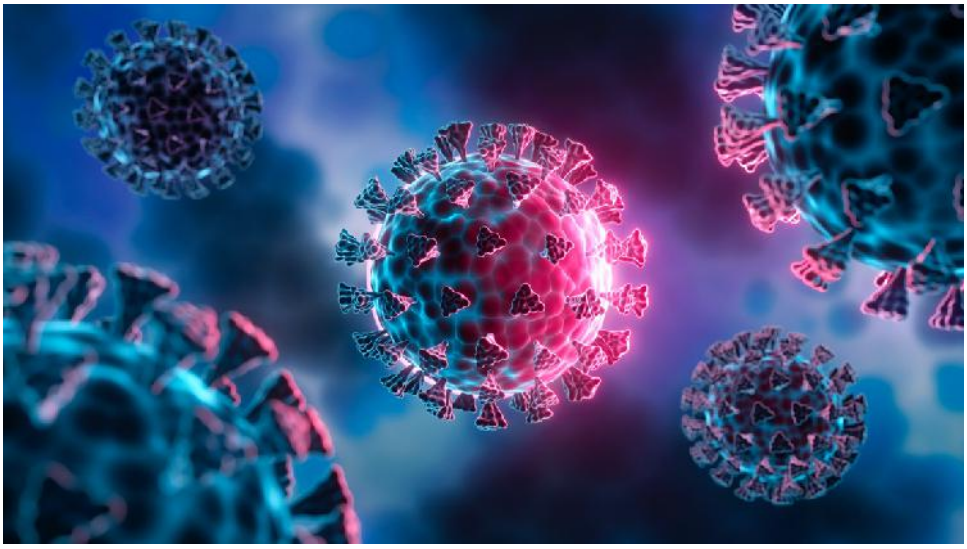

What we did

We surveyed 408 adults from Morwell and 204 from Sale approximately eight years after the mine fire. Using air pollution modelling conducted by CSIRO, we calculated each participant's level of exposure to smoke-related fine air particles < 2.5 micrometres in diameter ($PM_{2.5}$) during the mine fire. We then compared rates of COVID-19 infection in people with different levels of exposure. When we analysed the data we took into account other factors that influence lung health such as age, body mass, socioeconomic status, prior chronic respiratory conditions and tobacco smoking.

Analysis aims

Our research aimed to investigate whether adults who had been heavily exposed to air pollution from the 2014 mine fire were more likely to become infected with COVID-19 than adults who were less or minimally exposed.

Hazelwood HEALTH STUDY

What we found

From the 612 participants, 271 (44%) reported either that they had been diagnosed with COVID-19 or had symptoms consistent with COVID-19. We found that people who were most highly exposed to the mine fire smoke in 2014 were slightly more likely to have had COVID-19 than people who were less exposed. However, the finding of a link between smoke exposure and COVID-19 infection was quite weak and may have been a chance finding.

A detailed paper describing the findings from this analysis is freely available at
www.medrxiv.org/content/10.1101/2023.04.12.23288500v1

Considerations

The self-report of COVID-19 diagnoses or COVID-19 like symptoms may not have always been accurate. Further, there was the possibility that factors other than the mine fire air pollution were responsible for the small observed difference in COVID-19 infections reported by highly exposed compared with less exposed participants. However, it was also possible that previous smoke exposure did in fact increase vulnerability to COVID-19 and that measures to protect people from future air pollution events are important.

Where to from here?

The finding will be shared with relevant health and emergency services to ensure they are used to guide current health service provision and future responses to smoke events. The HHS is continuing to investigate the long term effects of smoke from the mine fire through health surveys and clinical testing.

The HHS is led by Monash University with collaborators from Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Department of Health.

Hazelwood HEALTH STUDY

Research Summary

The impact of coal mine fire smoke on lung ventilation in adults.

May 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air pollution incidents in Victoria's history. It caused considerable concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire. The HHS involves multiple research streams targeting different health outcomes and different vulnerable groups.

The Respiratory Stream is the part of the HHS that examines whether exposure to smoke from the mine fire is associated with respiratory symptoms, asthma control or decline in lung health.

Analysis aims

Three and a half years after the mine fire, this research aimed to discover whether adults who were more highly exposed to the mine fire smoke had poorer lung health than adults who were less exposed.

What we did

We worked with CSIRO to estimate the levels of fine particles in the smoke smaller than 2.5 thousandths of a mm in diameter ($PM_{2.5}$). Particles this fine can travel deep into people's lungs and some may even enter the bloodstream. We tested 346 adults from Morwell who were grouped into three levels of mine fire $PM_{2.5}$ exposure (low: daily average of 6 millionths of a gram per cubic metre of air ($\mu g/m^3$); medium: average of 12 $\mu g/m^3$; and high: average of 28 $\mu g/m^3$) and 173 adults from Sale who had little or no exposure.

Participants underwent a test of lung health called Multiple Breath Washout (MBW) which measures how evenly and efficiently gases we breathe, such as oxygen and nitrogen, are mixed and distributed throughout different parts of the lungs as people breathe in and out. Uneven mixing of gases in the lung (termed ventilation heterogeneity) occurs in people with asthma, chronic obstructive pulmonary disease or other small airway diseases, and is an indication of impaired lung function. We took into consideration other factors that could influence lung health, such as age, height, weight, cigarette smoking and participant's jobs that may have involved exposure to dust or fumes.

Hazelwood HEALTH STUDY

What we found

We found that as the level of mine fire $PM_{2.5}$ exposure increased, ventilation heterogeneity also increased, indicating uneven (poorer) mixing of gases in the part of the lung termed the conductive region. That is, three and a half years after the mine fire, higher levels of smoke exposure were associated with poorer lung function in adults. It is normal for lung ventilation to become more uneven as we age. However, our findings indicated that each 10 $\mu g/m^3$ increase in smoke exposure was associated with a change in ventilation that you would normally observe after approximately 7.6 years of aging. This finding was independent of participants' actual age.

A detailed paper describing the findings from this analysis can be requested from the Hazelwood Health Study researchers by email contact@hazelwoodhealthstudy.org.au or phone 1800 985 899

Where to from here?

Follow up testing of the Respiratory Stream participants is taking place so that longer term health effects of the mine fire smoke can be investigated and we can see if the changes in lung health resolve, persist or worsen.

Meet the team

Tom McCrabb
Brigitte Borg
Caroline Gao
Catherine Smith
David Brown
Jillian Ikin
Annie Makar
Tyler Lane
Michael Abramson
Bruce Thompson

Considerations

We cannot be absolutely certain that the mine fire smoke caused the change in lung ventilation because additional factors can affect lung health, such as genes, previous exposure to other sources of smoke, infections or access to health services. The small decreases in gas mixing that we measured may not mean that the affected adults will experience any noticeable lung problems now or in the future. However, people with symptoms like shortness of breath, wheezing, or frequent coughing should always have these checked by a doctor. Further, because a majority of adults from Morwell and Sale did not participate in the baseline Adult Survey from which the Respiratory Stream participants were drawn, it is possible that the findings do not truly represent lung health in the two communities.

The HHS is led by Monash University with collaborators from Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Victorian Department of Health.

Hazelwood HEALTH STUDY

Research Summary

Lung function changes in children exposed to mine fire smoke in infancy

May 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air quality incidents in Victoria's history. It caused considerable community concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire. The HHS involves multiple research streams targeting different health outcomes and different vulnerable groups.

The **Latrobe Early Life Follow up (ELF) Study** is the part of the Hazelwood Health Study that follows the health and growth of children who were younger than two years old when the fire occurred. This includes children whose mothers were pregnant with them at the time.

Analysis aims

Seven years after the mine fire, this research aimed to discover whether there were changes in the lung function of children who were exposed to mine fire smoke during infancy and if the changes previously observed persisted over time.

What we did

We invited children from the ELF Study who were exposed to mine fire smoke during infancy to attend clinical testing 7 years after the fire. We did a simple lung function test known as the forced oscillation technique on 115 children. It uses small vibrations to measure how easily air moves in and out of the lungs while the children breathe through a tube. We measured resistance to air flow and the stiffness of the lungs. By looking at where each child was on each day during the fire and how polluted the air was in that area, we were able to work out how much smoke they had been exposed to. When we analysed the data, we considered other factors that can affect lung function such as age, sex, height, and exposure to tobacco smoke.

Meet the team

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Shyamali Dharmage
Marita Dalton
Grant Williamson
Caroline Gao
Michael Abramson
Fay Johnston
Graeme Zosky

Hazelwood HEALTH STUDY

What we found

During testing previously undertaken 3 years after the fire, we found a link between mine fire smoke exposure and slightly increased lung stiffness. Further testing undertaken 7 years after the fire didn't find any link between mine fire smoke exposure and increased lung stiffness. Instead, there were moderate improvements in lung stiffness between the 3 and 7 year follow-up, of children exposed to smoke during infancy. This suggested that reductions in lung function observed at the 3-year follow-up had improved over time.

A detailed paper describing the findings from this analysis can be requested from the study team by emailing contact@hazelwoodhealthstudy.org.au

Considerations

Childhood is a period of rapid lung growth and varies considerably between children of different ages. Those variations, plus other factors that influence lung health, such as genetic makeup and exposure to tobacco smoke, may have impacted on our measurements.

Where to from here?

Further studies are needed to confirm these results. Childhood is a rapid period of lung development and growth. Therefore, lung function should be evaluated at further timepoints to fully understand the health implications of mine fire smoke exposure during infancy.

The Latrobe ELF Study is led by the Menzies Institute for Medical Research at the University of Tasmania with collaborations from Melbourne University and the Telethon Kids Institute.

The HHS is led by Monash University in collaboration with Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Victorian Department of Health.

Hazelwood HEALTH STUDY

Research Summary

Allergies in children seven years after the mine fire

June 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air quality incidents in Victoria's history. It caused considerable community concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire. The HHS involves multiple research streams targeting different health outcomes and different vulnerable groups.

The **Latrobe Early Life Follow up (ELF) Study** is the part of the Hazelwood Health Study that follows the health and growth of children who were younger than two years old when the fire occurred. This includes children whose mothers were pregnant with them at the time.

Analysis aims

We aimed to find out if exposure to smoke from the mine fire, either during pregnancy or during the first two years of childhood, was associated with increased likelihood of possible allergies seven years after the fire.

What we did

We invited children from the Early Life Follow-up Study who were exposed to mine fire smoke during pregnancy or the first two years of life, and children who were not exposed ('unexposed') to attend clinical testing. We collected blood samples in 103 children and tested them for specific allergic sensitisation to dust, fungi, cats, and grass pollen, as well as for an overall measure of allergy called total Immunoglobulin E (IgE). Allergic sensitisation occurs when the body's immune system mistakenly identifies an otherwise harmless substance as a threat and produces IgE antibodies in reaction.

We used air pollution data provided by CSIRO and movements of the pregnant mother and/or the child during the fire period to estimate how much mine fire smoke they were exposed to. We looked to see if higher amounts of mine fire smoke exposure were associated with a higher chance of having IgE antibodies (being overall allergic) or being allergic to dust, fungi, cats or grass pollen. In our analysis we considered other factors that could affect health of children, such as the child's age, social factors and usual background levels of air pollution, to distinguish the specific influence of the smoke from the mine fire.

Hazelwood HEALTH STUDY

What we found

Compared to babies with low mine fire smoke exposure, we found that the babies of mothers who were exposed to higher levels of mine fire smoke during pregnancy or those who directly breathed the smoke in their first two years of life, were at no higher risk of a positive blood test indicating overall allergy or specific allergies to dust, cats, fungi, or grass pollen seven years after the fire.

A detailed paper describing the findings from this analysis can be requested from the study team by emailing contact@hazelwoodhealthstudy.org.au

Where to from here?

These findings will be shared with relevant organisations and the scientific community to ensure they are used to shape services for the future health of the Latrobe Valley. Additionally, findings will help guide responses to severe smoke events in the future.

Considerations

Although we did not find a link at this stage between exposure to the fire and the risk of common allergies, this risk generally continues to increase until children reach adolescence, so there is a possibility that these results could change in the next few years. Additionally, having a positive result to an allergy test does not mean that the child will necessarily have clinical symptoms. It is also important to mention that the number of participants in our study was small, and that may have limited our ability to detect a subtle difference between exposed and unexposed children if it was present. Finally, this study did not test for a range of possible allergies (e.g., food, dogs, tree pollen), thus our results cannot tell us anything about if there was a link between the smoke and those allergies.

Meet the team

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The Latrobe ELF Study is led by the Menzies Institute for Medical Research at the University of Tasmania with collaborations from Melbourne University and the Telethon Kids Institute.

The HHS is led by Monash University in collaboration with Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Victorian Department of Health.

Hazelwood HEALTH STUDY

Research Summary

Self-reported respiratory health after the Hazelwood coalmine fire and the COVID-19 pandemic

August 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air quality incidents in Victoria's history. It caused considerable concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study was established to examine the impacts of the mine fire. The Hazelwood Health Study involves multiple research streams targeting different health outcomes and different vulnerable groups.

Analysis aims

8.5 years after the mine fire, this research aimed to investigate whether adults who had been heavily exposed to smoke from the fire were more likely to report respiratory symptoms than adults who were less or minimally exposed. The analysis also aimed to investigate whether the relationship between mine fire smoke exposure and respiratory symptoms was made worse by COVID-19 infection.

What we did

In 2016/2017, approximately 2.5 years after the mine fire event, 3,096 Morwell and 960 Sale residents completed the Hazelwood Health Study Adult Survey. Participants answered questions about their locations on different days during the mine fire (e.g. home, work or leave). Based on those locations, air pollution data modelled by CSIRO was used to estimate each participant's level of exposure during the fire to fine airborne smoke particles less than 2.5 thousandths of a mm in diameter ($PM^{2.5}$). Participants also reported whether they had experienced any of seven respiratory symptoms in the year prior to the survey; those being current wheeze, chest tightness, shortness of breath at night, shortness of breath at rest, nasal symptoms, chronic cough and phlegm. At that time, we found that people who had been exposed to higher levels of $PM^{2.5}$ (that is, higher levels of mine fire smoke) were more likely to report chronic cough and current wheeze than people who had been exposed to less smoke.

In 2022, approximately 8.5 years after the fire, 612 participants were resurveyed. We looked to see whether their previously reported respiratory symptoms had improved, stayed the same or worsened. We also investigated whether contracting COVID-19 had made any difference to the association between mine fire smoke exposure and respiratory symptoms. This analysis took into consideration other factors that could influence health such as age, socioeconomic status and cigarette smoking.

Hazelwood HEALTH STUDY

What we found

Compared with the symptoms reported 2.5 years after the event, mine fire smoke-exposed participants reported a sustained and worsening increase in chronic cough and possibly a worsening increase in current wheeze, 8.5 years after the event. That is, the effect of mine fire smoke exposure on cough and wheeze seemed to have increased over time.

Mine fire smoke-exposed people who had contracted COVID-19, compared to mine fire smoke-exposed people who had not contracted COVID-19, were more likely to report shortness of breath at night, chronic phlegm and possibly chest tightness. That is, mine fire smoke exposure and COVID-19 combined, resulted in more respiratory symptoms than mine fire smoke exposure alone.

A detailed paper describing the findings from this analysis is freely available at
www.medrxiv.org/content/10.1101/2023.04.12.23288500v1

Meet the team

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Considerations

Only 34% of Morwell adults participated in the original 2016/2017 Adult Survey and, of those, 26% participated in the 2022 Survey. Whilst this was comparable to participation rates in other Australian research studies, there is the possibility that participants were not completely representative of their town.

Where to from here?

The finding will be shared with relevant health and emergency services to ensure they are used to guide current health service provision and future responses to smoke events. The HHS is continuing to investigate the long term effects of smoke from the mine fire through health surveys and clinical testing.

The HHS is led by Monash University with collaborators from Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Department of Health.

Hazelwood HEALTH STUDY

Research Summary

Blood vessel health in young children 7 years after the coalmine fire.

October 2023

Background

The fire in the Morwell open cut brown coal mine adjacent to the Hazelwood Power Station blanketed the town of Morwell and the surrounding area in smoke and ash for six weeks in February and March 2014. The smoke event was recognised as one of the most significant air quality incidents in Victoria's history. It caused considerable concern within Morwell and the broader community. In response to these concerns, and following extensive community consultation, the Hazelwood Health Study (HHS) was established to examine the impacts of the mine fire. The HHS involves multiple research streams targeting different health outcomes and different vulnerable groups.

The **Latrobe Early Life Follow up (ELF) Study** is the part of the Hazelwood Health Study that follows the health and growth of children who were younger than two years old when the fire occurred. This includes children whose mothers were pregnant with them at the time.

Analysis aims

Seven years after the mine fire event, this research aimed to discover whether smoke from the fire affected the health of blood vessels in very young children from the Latrobe Valley, including children whose mothers were pregnant with them at the time. The study also aimed to determine if usual levels of background air pollution were associated with blood vessel health in early childhood.

What we did

We invited children from the ELF Study who were exposed to mine fire smoke during infancy or in the womb to attend clinical testing in 2017 (3-year follow-up) and/or 2021 (7-year follow-up). We measured blood vessel thickness and stiffness using ultrasound, in 248 children at the 3-year follow-up and 163 children at the 7-year follow-up.

We worked out how much smoke each child had been exposed to by looking at where the child was each day during the fire and how polluted the air was in that area. When we analysed the data, we considered other factors that can affect lung function such as age, sex, height, and exposure to tobacco smoke.

Hazelwood HEALTH STUDY

What we found

In children who were up to 2 years of age at the time of the fire, the 2017 clinical testing showed weak evidence that higher smoke exposure was linked to very small increases in blood vessel stiffness, indicating poorer blood vessel health 3 years after the event. However, the 2021 clinical testing showed a modest improvement in blood vessel stiffness, indicating possible recovery 7 years after the event.

In children whose mothers were pregnant with them at the time of the fire, the 2017 testing showed no link between higher smoke exposure and poorer blood vessel health. However, the 2021 testing did show a link between higher smoke exposure and a mild increase in vessel stiffness, indicating poorer blood vessel health 7 years after the event. This group of children also had increased vessel stiffness linked to exposure to background air pollution.

A detailed paper describing the findings from this analysis can be requested from the study team by emailing contact@hazelwoodhealthstudy.org.au

Considerations

We cannot rule out the possibility that the results occurred by chance, or were due to other unmeasured factors that can affect blood vessel health. Vessel growth varies a lot between children of different ages and genders. Vessel stiffness does not automatically mean that children will later develop blood vessel or heart problems. Stiffer blood vessels are one of many things, including genetic make-up, smoking tobacco, stress, diet and physical activity that can influence the risk of heart disease in later life.

Where to from here?

Further studies are needed to confirm these results. Childhood is a rapid period of lung development and growth. Therefore, lung function should be evaluated at further timepoints to fully understand the health implications of mine fire smoke exposure during infancy. A 3rd round of clinical testing is scheduled for 9 years after the fire.

Meet the team

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The Latrobe ELF Study is led by the Menzies Institute for Medical Research at the University of Tasmania with collaborations from Melbourne University and the Telethon Kids Institute.

The HHS is led by Monash University in collaboration with Menzies Institute for Medical Research, Federation University, The University of Adelaide, and CSIRO.

The research was funded by the Victorian Department of Health.

Understanding the impact

of the Hazelwood mine fire on the health of the Latrobe Valley community

Hazelwood HEALTH STUDY

The Hazelwood mine fire had a major impact on the Latrobe Valley community. As well as being an incredibly stressful time for locals living in the area, it understandably caused many people to have concerns about the length of time they were exposed to smoke from the fire and its possible health effects. In 2014, the Hazelwood Health Study was set up to monitor the long-term health of community members. This leaflet provides a snapshot of the Study's findings to date.

Health information has now been collected from more than 70,000 people

The Hazelwood Health Study, now in its 9th year, is led by Monash University, the University of Tasmania and Federation University. Data collected includes:

70,000
Health service information from more than 70,000 people across the Latrobe Valley and wider Gippsland

10,000
The educational results of more than 10,000 school children

4,500
Cancer information from more than 4,500 people

4,000
Physical symptoms, mental health and smoke exposure information from more than 4,000 adults

3,500
Pregnancy and birth information from more than 3,500 women

1,000 + 500
Heart and lung information from more than 1,000 adults and 500 young children

300
Mental health information from more than 300 school children.

INTERESTING

While the Study shows that the fire has contributed to ongoing health problems in Morwell and surrounding areas, it has also shown that some of those problems are improving.

The heart and lung health of adults was affected but there are signs of improvement

CARDIOVASCULAR HEALTH (heart and blood vessels)

- Medications dispensed
- Risk of death from cardiovascular conditions

RESPIRATORY HEALTH (lungs and breathing)

- Medications dispensed
- Ambulance call-outs
- Emergency department attendances
- Hospital admissions
- Specialist visits (among men)

NO CHANGE in risk of death from respiratory conditions

Fire-related distress persists in some adults

AT TIME OF FIRE

- Mental health-related consultations, prescriptions, ambulance call-outs and hospital admissions

2.5 YEARS LATER

14% of adults reported symptoms consistent with post-traumatic stress disorder (PTSD)

Moderate levels of distress reported by adults in Morwell, with higher levels of distress among people who were exposed to more smoke

Distress was most common among younger adults and those who already had respiratory or mental health conditions

5.5 YEARS LATER

- Fire-related distress (especially among younger adults) compared to the levels reported 2.5 years after the fire – this may have been partly due to additional smoke exposure during the 2019 Black Summer fires

2.5 to 3 years later

- Self-reported heart attacks and high blood pressure (but reported by very small numbers of people)

3.5 to 4 years later

- **NO DIFFERENCES** in cardiovascular disease, reduced heart function, heart muscle damage, abnormal heart rhythm or abnormal blood vessel health

- Respiratory symptoms, e.g. cough, shortness of breath
- Chest tightness
- Chronic (long-term) cough
- Lung stiffness
- Chronic obstructive pulmonary disease (COPD) among non-smokers
- Chronic cough among smokers
- Control of asthma

Health issues in babies and young children continue to be monitored

Pregnant women exposed to mine fire smoke

- Risk of gestational diabetes

Babies who were in the womb at the time of the fire

After birth:

- Symptoms such as runny nose, cough and wheeze
- Healthcare visits
- Upper respiratory infections (colds)

Very young children

- Use of antibiotics, steroid creams and asthma medications
- Visits to GPs and emergency departments

Children who were tested several years later

3 years after the fire

- **Stiffness of lungs and blood vessels**

6 years after the fire

NO stiffness of lungs detected, meaning this may have resolved

DID YOU KNOW?

No differences in cardiovascular health several years after the fire suggests that earlier problems may now have resolved. However, the data suggests ongoing impacts on lung health.

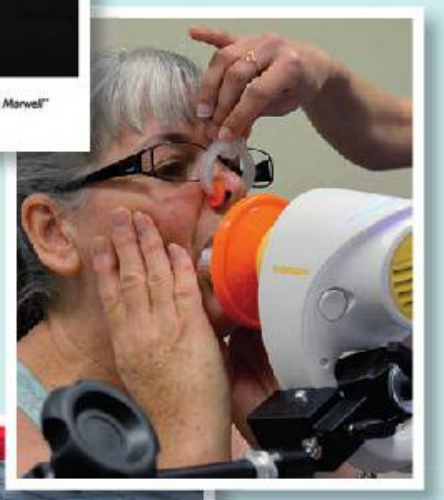
Tracking educational and mental health outcomes in school children

- **Specialist school students had particular difficulties at the time of the fire**
- **1.5 years after the fire:**
  - Most mainstream school students did not have ongoing problems, but about 1 in 5 students (22%) reported post-traumatic stress symptoms
  - Morwell students exposed to smoke reported more distress than non-Morwell students, with primary school students reporting more symptoms than secondary students
- **NAPLAN (National Assessment Program – Literacy and Numeracy) results:**
  - Compared with before the fire, NAPLAN results for Morwell students after the fire showed a 4–5 month delay in educational achievement across all learning areas, which had not fully recovered several years later (based on results for year 7 and 9 students)

Findings related to older people, communication, community wellbeing and recovery

In addition to the specific health and education impacts described in this leaflet, the Hazelwood Health Study has also found that:

- Voices of older people were paid little attention during the event and there was little support for them, especially those living independently
- The public health response at the time was limited by a lack of evidence about the likely health impacts of the mine fire
- There were problems with official communication about the mine fire, which led to confusion, mixed messaging, and a loss of trust in the authorities who were dealing with the crisis
- Because of this, local media outlets and social media groups were important in filling communication gaps and representing community concerns
- As well as health considerations, community recovery includes broader wellbeing, job creation and sustainability, along with careful consideration of the implications of an energy transition away from coal



Study findings drive positive change for Latrobe Valley and beyond

Although the Study can't change what happened in the past, it is providing important learnings. The research findings are regularly shared with local and Statewide organisations such as the Latrobe City Council, the Gippsland Primary Health Network, the Latrobe Health Advocate, the Latrobe Health Assembly and the Department of Health.

Here are some examples of how the Study has helped shape services for the ongoing health of the Latrobe Valley or changed the way authorities now respond to bushfire and other smoke-related events to protect the health of the community:

Contributing to decisions made during the Black Summer bushfires

During the 2019 Black Summer bushfires across eastern Australia and Tasmania, study findings were used in making decisions to evacuate smoke-affected communities and supply air purifiers in evacuation shelters.

Informing national guidelines for smoke events

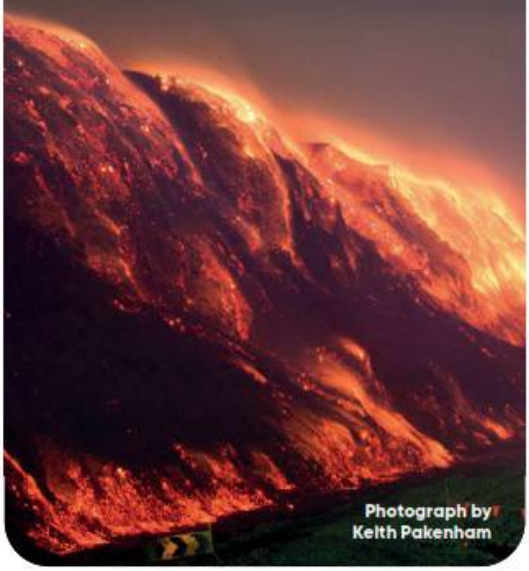
The Study's findings have also helped inform national guidelines for prolonged smoke events, showing the importance of minimising pregnant women's exposure to air pollution.

Prompting extra mental health services for school-aged children

In response to the Study, the Department of Health recognised the increased levels of distress in school-aged children, which led to the establishment of a clinical pathway and the increased provision of mental health services in the region.

CONSEQUENCES FOR COAL MINE OPERATORS

Study findings were included in the 2019 Supreme Court trial that found the Hazelwood coal mine operators guilty of 10 Worksafe breaches, as well as an earlier trial that found them guilty of three Environment Protection Act breaches. The mine operators were found guilty of polluting the atmosphere so as to make it harmful to health.



Photograph by Keith Pakenham

Ongoing research

The Hazelwood Health Study is continuing, which may reveal further evidence of health improvements and lessons for the future. We will share the latest findings with the community as they become available. If you were in the Latrobe Valley at the time of the fire and have concerns about your health or that of your family members, please see your GP.

Hazelwood HEALTH STUDY

For more information about the Hazelwood Health Study, go to **https://hazelwoodhealthstudy.org.au/**

We would like to express our sincere thanks to everyone who has participated in the Hazelwood Health Study.