Associations between self-reported respiratory symptoms and non-specific psychological distress following exposure to a prolonged landscape fire

Running title: Respiratory and distress symptoms after fire

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Conflict of interest statement

Michael Abramson holds investigator-initiated grants for unrelated research from Pfizer and Boehringer-Ingelheim. He has also undertaken an unrelated consultancy for Sanofi. The remaining authors report no relationships that could be construed as a conflict of interest. The funders had no role in the design of the study; collection, analyses, or interpretation of data; writing the manuscript, or the decision to publish the results.

Data Accessibility statement

Restrictions apply to the availability of these data. Data were obtained from participants and are available from the authors with the permission of the Victorian Department of Health.

Statement of contributions

RS led the drafting of the work and revising it critically, and contributed to the analysis and interpretation of the data. MC and JI contributed to the conception and design of the work, the acquisition of data, drafting the work and revising it critically. CG and JB contributed to the analysis and interpretation of data, drafting
the work and revising it critically. DB contributed to the acquisition of data, drafting the work and revising it critically. ADM contributed to the conception and design of the work, the acquisition and interpretation of data, drafting the work and revising it critically. AMF, EB, DM, MS, JW and MA contributed to the conception and design of the work, the interpretation of data, drafting the work and revising it critically. All authors approved the final version to be published and take public responsibility for appropriate portions of the content. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.
Associations between self-reported respiratory symptoms and non-specific psychological distress following exposure to a prolonged landscape fire

Abstract: We investigated the association between respiratory symptoms and psychological distress in the context of a prolonged smoke event, and evaluated whether smoke exposure, or pre-existing respiratory and mental health conditions, influenced the association. 3096 residents of a rural town heavily exposed to smoke from the six-week Hazelwood coal mine fire, and 960 residents of a nearby unexposed town, completed Kessler's psychological distress questionnaire (K10) and a modified European Community Respiratory Health Survey. Logistic regression models evaluated associations between distress and respiratory symptoms, with interactions fitted to evaluate effect modification. Smoke exposed participants reported higher levels of distress than those unexposed, and participants reporting respiratory symptoms recorded higher levels of distress than participants without respiratory symptoms, irrespective of exposure. 5-unit increments in K10 score were associated with 21 to 48% increases in the odds of reporting respiratory symptoms. There were significant interactions with pre-existing asthma, chronic obstructive pulmonary disease and mental health conditions, but not with smoke exposure. Although participants with pre-existing conditions were more likely to report respiratory symptoms, increasing distress was most strongly associated with respiratory symptoms among those without pre-existing conditions. Communities
exposed to landscape fire smoke could benefit from interventions to reduce both psychological and respiratory distress.

**Keywords:** Respiratory symptoms, Psychological distress, K10 scale, surveys, Landscape fires

**Introduction**

People with psychological illnesses have been shown to have an increased likelihood of chronic respiratory conditions such as chronic obstructive pulmonary disease (COPD) and asthma (Himelhoch et al., 2004). Similarly, people with chronic respiratory diseases demonstrate elevated risk of comorbid psychological symptoms such as anxiety and depression (Goodwin, Jacobi, & Thefeld, 2003; Maurer et al., 2008). For example, the prevalence of depressive symptoms has been shown to be almost three times higher in people with COPD compared to people without (Zhang, Ho, Cheung, Fu, & Mak, 2011), and the odds of developing depression and anxiety have been shown to be close to double in adolescents with asthma compared to those without (Lu et al., 2012). A review of the physical and psychological consequences of COPD-related dyspnoea (difficulty breathing) found that some patients have anticipatory fear of developing dyspnoea which subsequently resulted in worsening of their symptoms (Hanania & O'Donnell, 2019). Anxiety and depression, when present in COPD patients, are associated with increased mortality and length of
hospital stays, and decreased quality of life and functional status (Pumar et al., 2014). A South Australian study of chronic breathlessness and health-related quality of life, found that chronic breathlessness was associated with clinically meaningful decrements in the physical (PCS) and mental (MCS) components of the Short Form-12 (SF-12) quality of life scale (Currow et al., 2017). Kullowatz and colleagues investigated the effect of stress on lung function testing in individuals with asthma (Kullowatz et al., 2008). They found that worsening mood and affect resulted in decreases in Forced Expiratory Volume in 1 second (FEV₁) and increases in Fractional exhaled nitric oxide (FeNO), however similar findings were not found for healthy controls (Kullowatz et al., 2008). Anxiety and depressive disorders were also found more commonly in people with asthma than those without (Scott et al., 2007).

Severe air-pollution generating events such as landscape fires can adversely impact both the respiratory and psychological health of effected communities. However, the association between respiratory and psychological symptoms in the context of such events is not well understood. Ho et al (2014) investigated the impact of widespread severe haze in Southeast Asia in 2013, triggered by planned burns in Indonesia for agricultural purposes, on subsequent psychological distress using the Impact of Event Scale-Revised (IES-R) and physical symptoms (Ho et al., 2014). The authors found that the 2013 Haze crisis was associated with physical symptoms including breathing difficulties, and that the number of physical symptoms was associated with the IES-R mean intrusion score, mean hyper-arousal score, total mean
score and total IES-R score (p < 0.05) (Ho et al., 2014). A systematic review evaluating the consequences of seasonal haze from forest fires in South East Asian countries demonstrated increases in respiratory morbidity, including asthma, bronchitis and cough (Ramakrishnan et al., 2018). However, there was no consistent evidence of an association between air pollution and psychological symptoms (Ramakrishnan et al., 2018).

In February 2014, an out of control forest fire (bushfire, wildfire or landscape fire) entered a disused section of the Morwell open-cut brown coal mine adjacent to the Hazelwood power station in the Latrobe Valley, South-eastern Australia. The resulting fire burned for approximately six weeks, cloaking the nearby rural town of Morwell and much of the Latrobe Valley with smoke and ash. The Hazelwood Health Study (www.hazelwoodhealthstudy.org.au) was established to assess the potential long-term health effects of the mine fire’s smoke exposure upon the population of Morwell and other parts of the Latrobe Valley (Ikin et al., 2020; Melody et al., 2020). The Hazelwood Health Study’s Adult Survey presented evidence of dose-response associations between levels of smoke exposure and respiratory symptoms such as cough, wheeze and phlegm between two to three years later (Johnson, Gao, et al., 2019). The Adult Survey, complemented by in-depth qualitative interviews, also demonstrated associations between smoke exposure, psychological distress and intrusive thoughts two to three years after the event (Maybery et al., 2020).
This new analysis aimed to investigate the association between self-reported respiratory symptoms and psychological distress in the context of mine fire smoke exposure, and evaluate whether smoke exposure, or pre-existing respiratory and mental health conditions, influence the association between self-reported respiratory symptoms and distress.

Methods

Study Design & Setting

The Adult Survey stream of the Hazelwood Health Study included a cross-sectional survey of a range of long-term physical and mental health outcomes. Detailed methods have been published elsewhere (Ikin et al., 2020). In brief, the Adult Survey was conducted between May 2016 and February 2017 in the semi-rural Latrobe Valley region of South-eastern Australia, with the mine located on the boundary of the Morwell township. Mine fire exposed participants were drawn from Morwell. Unexposed participants were drawn from Sale, a town 50 kilometres further east of the coal mine.

High resolution air pollution modelling of the mine fire was undertaken by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans & Atmosphere, and focused on two major pollutants; namely airborne particles smaller than 2.5 thousandths of a millimetre (PM$_{2.5}$) and carbon monoxide (Emmerson, Reisen, Luhar, Williamson, & Cope, 2016; Luhar, Emmerson, Reisen, Williamson, & Cope, 2020). The modelling showed that the hourly averaged concentration of PM$_{2.5}$ in
southern Morwell reached as high as 3700 micrograms (millionths of a gram) per cubic metre of air during the early period of the fire compared with usual levels of about 6 micrograms per cubic metre. Modelled peak hourly concentrations of CO reached 60 parts in one million, with usual levels being about 0.07 parts in one million.

Participants

The Adult Survey exposed (study) group were defined as people who lived within the township boundary of Morwell, and were 18 years or older, on the 31st of March 2014. The eligible unexposed (comparison) group were also people aged 18 years or older on the 31st of March 2014, and who lived at that time within one of 16 selected Statistical Areas Level 1 (SA1s) within Sale which had comparable median age, household size, Socio-Economic Indexes for Areas (SEIFA) and population stability as Morwell. Eligible participants were identified using the Victorian electoral roll and were invited to take part in the Adult Survey by mail to their last known address. Non-responders were followed up via telephone, mail and public advertisements. The electoral roll was considered a near-to-complete sampling frame from which to identify residents because, with few exceptions, electoral registration is compulsory for Australian citizens aged 18 years or older (Victorian Electoral Commission). Exceptions include incapacity, incarceration and living overseas. Data provided by the Electoral Commission excluded a small but unknown number of silent electors, for whom the Commission could not disclose contact details.

Variables

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Health data were collected via self-report survey, conducted over-the-phone, online or on paper. Variables included participants’ demographic and socio-economic indicators (age, gender, marital status, education level and employment status). A slightly modified version of the third European Community Respiratory Health Survey (ECRHS III) (Burney, Luczynska, Chinn, & Jarvis, 1994) was used to identify respiratory symptoms in the previous 12 months, asthma and COPD. The ECRHS is one of the largest international studies of respiratory health with 56 research centres across 25 countries (https://www.ecrhs.org). ECRHS has been well validated and accepted as a standard epidemiological tool (Sunyer, Basagaña, Burney, & Antó, 2000). Refer to Table S1 for the list of ECRHS III questions included in this study. The Kessler 10 item psychological distress scale (K10) was used to assess non-specific psychological distress in the previous four weeks (Kessler et al., 2002). The K10 was scored from 10-50, and the results were categorised: a score of 10-15 was categorised as low, 16-21 as moderate, 22-29 as high, and 30 or above as very high distress (https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4817.0.55.001Chapter92007-08). The reliability and validity of the K10 has been established across a number of settings (Donker et al., 2010; Hides et al., 2007; Spies et al., 2009). Self-reported doctor diagnosed anxiety, depression and other mental health conditions were also collected.

To identify participants whose occupational histories may have influenced their respiratory health, participants reported any paid jobs held for at least six months which may have involved exposure to dust, fumes, smoke, gas vapour or mist,
including jobs with emergency services or employment in the Latrobe Valley coal mines or power stations. Based upon responses, participants were divided into three occupational exposure categories: i. “not exposed” (jobs not involving exposure to dust, fumes, smoke, gas vapour or mist); ii. “coal mine or power station exposed”; iii. “exposed, but not coal mine/power station” (jobs involving exposure to dust, fumes, smoke, gas vapour or mist, but not at a coal mine or power station). Respondents who had ever smoked at least 100 cigarettes or a similar amount of tobacco in their lifetime were defined as smokers as per the World Health Organization definition (WHO, 1998) and further categorised as current or former smokers.

Statistical Methods

Simple descriptive statistics were used to compare participant characteristics between those who reported respiratory symptoms and those who did not. Crude differences were compared using Pearson chi-squared tests for categorical variables and t-tests for numeric variables. Mean and Standard Deviation (SD) of K10 total scores were reported for each location (unexposed participants with/without respiratory symptoms vs exposed participants with/without respiratory symptoms). Analysis of variance (ANOVA) was used to assess whether the mean K10 scores differed by location and symptoms.

Associations between psychological distress (K10) and each self-reported respiratory symptom were primarily investigated using multivariate logistic
regression controlling for mine fire exposure (Morwell vs Sale) and other confounding variables including age, gender, employment status, education, marital status, smoking status, occupational exposure, pre-existing asthma or COPD and history of mental health conditions. Sample weightings were applied to reduce participation bias. Interactions between K10 and a set of risk factors (mine fire exposure, pre-existing asthma and/or COPD and a history of mental health conditions) were tested separately to evaluate whether mine fire exposure and pre-existing conditions modified the associations between psychological distress and respiratory symptoms.

Marginal plots of the averaged predicted probability of respiratory symptoms were used to show how any associations between K10 and respiratory symptoms were modified by these risk factors. Due to difficulty in interpretation of ORs when prevalence rates are high, relative risks (RR) for the above investigations were estimated using the robust Poisson model, via generalised linear regression models with Poisson distribution and log link estimated with a robust error estimator (Zou, 2004). The commonly used log-binomial model was not possible due to convergence issues (Williamson, Eliaziw, & Fick, 2013).

Missing data were dealt with using multiple imputation by chained equations (MICE) (Royston & White, 2011; Donald B. Rubin, 1996) with 20 iterations. All individual K10 items were included in the imputation model and K10 total scores were imputed passively. A total of 20 imputed datasets were used, and regression model results were combined using Rubin’s rule (Donald B Rubin, 2004). Overall
effects were expressed as the adjusted odds ratios (OR) for self-reported respiratory symptoms and 95% confidence intervals (CI), associated with each 5 unit increase in K10 score after controlling for mine fire exposure, age, gender, employment, education, marital status, smoking, occupational exposures, pre-existing respiratory and mental health conditions. All statistical analyses were conducted using Stata 15 (StataCorp, 2017).

**Ethics Approval**

The protocol for the Adult Survey was approved by the Monash University Human Research Ethics Committee (Project numbers 6066 and 25680). Participants provided informed consent. All procedures were in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Results**

Recruitment results have been previously described in detail (Ikin et al., 2020; Johnson, Gao, et al., 2019). In brief, 3037 Morwell residents (34%) and 957 Sale residents (23%) from the Victorian electoral roll, and an additional 59 Morwell and 3 Sale residents not on the electoral roll, were recruited (Ikin et al., 2020). There was a total of 4,056 participants in this analysis. As shown in Table 1, over half (53%) were female and two thirds (68%) were residents of Morwell. Mean (SD) age was 50.5 (18.9) years. Several factors were associated with self-reported respiratory symptoms, including being female, living in Morwell, unemployed or unable to work, having a
lower education level, being a current or former smoker, occupational exposure to
dust, fumes, smoke, gas vapour or mist; and having pre-existing asthma/COPD or
mental health conditions. The proportion of participants reporting moderate, high or
very high distress was substantially higher among those with respiratory symptoms
(42%) compared with those without (15%).

The distribution of K10 scores was evaluated for individual respiratory symptoms
and exposure groups, shown in Table 2. For every self-reported respiratory symptom,
exposed (Morwell) participants who reported the symptom had higher distress levels
on the K10 than exposed participants without the symptom. Similarly, unexposed
(Sale) participants who reported the symptom had higher distress levels on the K10
than unexposed participants without the symptom. In other words, the presence of
respiratory symptoms was associated with higher distress levels in participants with
and without mine fire smoke exposure. The lowest K10 scores were observed among
Sale participants who did not report any respiratory symptom.

For all participants, the associations between 5 unit increments in K10 scores and
odds of reporting respiratory symptoms are presented in Table 3. For each 5-unit
increment in K10 score, there was an estimated 21 to 48% increase in the odds of
reporting different respiratory symptoms after adjustment for exposure (Morwell vs.
Sale), age, gender, employment, education, marital status, smoking, occupational
exposures, and pre-existing respiratory and mental health conditions. The estimated

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effects were largest for shortness of breath (adj OR 1.48 95% CI 1.38,1.59) and smallest for current nasal symptoms (adj OR 1.21 95% CI 1.14,1.28).

Whether the associations between distress and self-reported respiratory symptoms were related to mine fire exposure, or history of doctor-diagnosed respiratory or mental health conditions, was further evaluated in three sets of interaction models based on the multivariate logistic regression (Figure 1). Within both exposure groups there was evidence of an association between increments in K10 and increased reporting of respiratory symptoms. However, there was no evidence of an interaction, indicating that exposure to Hazelwood mine fire smoke did not modify the association between distress and respiratory symptoms. Further, there was evidence of associations between increments in K10 and increased reporting of respiratory symptoms in participants with, and without, previous asthma/COPD. However, there was also several significant interactions, indicating that the association between increments in K10 and increased reporting of several respiratory symptoms was greater in those with no previous history of asthma/COPD compared to those with a history of asthma/COPD. For example, amongst participants with no history of asthma/COPD there was an estimated 44% (95% CI: 34-56%) increase in the odds of reporting chronic cough for each 5 unit increase in K10. However, amongst participants with a history of asthma/COPD, there was an estimated 23% (95% CI: 13-34%) increase. Figure 1 also demonstrates evidence of associations between increments in K10 and increased reporting of respiratory symptoms in participants
with, and without, a history of mental health conditions. Significant interactions for chest tightness, nocturnal shortness of breath, resting shortness of breath and nasal symptoms, indicate that the associations between increments in K10 and increases in these symptoms were greater in those with no previous history of mental health conditions compared to those with a history of mental health conditions. For example, participants without a history of mental health conditions were estimated to have a 77% (95% CI: 60-97%) increase in odds of reporting nocturnal shortness of breath per 5 unit increase in K10, whereas participants with a history of mental health conditions were estimated to have only a 29% (95%CI:19-41%) increase.

The marginal plots of averaged predicted probability of respiratory symptoms from the asthma/COPD and mental health interaction models are provided in Supplementary Figures S1 and S2. When participants had low levels of psychological distress, the probabilities of reporting different types of respiratory symptoms were much higher in those with asthma/COPD compared with those without. However, higher K10 scores were found to be associated with greater increases in probability of reporting respiratory symptoms in those without asthma/COPD. Hence, the probability of reporting respiratory symptoms became almost comparable between those with and without asthma/COPD, when K10 scores were high. Similar trends were also observed in mental health interaction models, except that the predicted probabilities of respiratory symptoms at high distress levels were higher among those without a mental health history compared with those with a history.
To assist with interpretation of ORs with higher outcome rates, RRs estimated from robust Poisson models are provided in the Supplement Table S2 and Figure S1. Those results should be interpreted with care, as robust Poisson models may estimate probabilities of outcome events over one and bias the estimated effect size when the prevalence of the outcome is very high (Williamson et al., 2013).

Discussion

This analysis examined the associations between nonspecific psychological distress and respiratory symptoms in a cohort of adults with, and without, exposure to smoke from a six week mine fire event up to three years earlier. Increments in psychological distress, measured using K10 scores, were strongly associated with increased likelihood of reporting respiratory symptoms in participants both with and without mine fire exposure. These associations were present after adjusting for confounding factors and possible effects of comorbidities, including asthma, COPD or previous mental health conditions. The associations between psychological distress and respiratory symptoms were stronger among those without pre-existing asthma/COPD or mental health conditions compared with those with pre-existing comorbidities.

Our findings are consistent with some previous studies. Friedman et al. investigated survivors following the 2001 World Trade Centre attacks and found...
that individuals with a previous mental health condition were more predisposed to ongoing respiratory illness. Comorbid respiratory symptoms and mental illness were associated with a greater decrease in quality of life compared to respiratory symptoms without associated mental illness. As the interval from disaster exposure to current illness increased, mental illness was the most strongly identified determinant of persistent lower respiratory symptoms (Friedman et al., 2016). A Swedish cohort study investigated the relationship between psychological symptoms and dyspnoea in the general population (Neuman et al., 2006). Although symptoms related to anxiety and depression impacted on the development of dyspnoea, there appeared to be less evidence that dyspnoea induced psychological symptoms (Neuman et al., 2006).

Overall, a third of participants in our study reported to have ever been diagnosed with a mental health condition. This is consistent with the estimated national prevalence of mental ill-health: 20% for 12-months and 45% for life-time (Australian Bureau of Statistics, 2007). Relative to the 2017-18 National Health Survey (Australian Bureau of Statistics, 2018) a higher proportion of participants reported high to very high psychological distress on the K10 (18% of all participants, or 22% of participants with respiratory symptoms, versus 13% in the 2017-18 National Health Survey). However, recent Australian data utilising an online survey (Klein, Tyler-Parker, & Bastian, 2020) suggests that the face to face National Health Surveys may underestimate community prevalence.
Previous studies have demonstrated the relationship between the mind and the body, and how a worsening of psychological symptoms can result in worsening physical symptoms, and vice versa (Hanania & O'Donnell, 2019; Kullowatz et al., 2008). Increases in stress and anxiety can manifest in physical symptoms of palpitations, shortness of breath, muscle tension and trouble sleeping, just to name a few. Low grade inflammation has been considered one possible mechanism in this relationship (Osimo, Baxter, Lewis, Jones, & Khandaker, 2019; Tayefi et al., 2017). A recent meta-analysis of 17 studies reported the odds of low grade inflammation to be 46% higher in depressed compared to healthy participants (OR 1.46, 95%CI 1.22-1.75) (Osimo et al., 2019). A study of almost 10,000 adults in Iran, reported depression and anxiety to be strongly associated with high sensitivity C-reactive protein (hs-CRP; a marker of systemic inflammation), Body Mass Index and smoking (Tayefi et al., 2017).

People with chronic physical conditions are also at greater risk of poor mental health due to factors of social isolation and fear regarding one’s own health and wellbeing (Canadian Mental Health Association, 2008). Concurrent chronic mental health and physical conditions can result in significantly decreased quality of life and can lead to longer illness duration (Patten, 1999). Those with mental illness are also predisposed to developing comorbid poor physical health, due to many factors including side effects from medications used to treat mental health conditions, and poor social determinants of health. Compared to national comparison subjects
matched on age, gender and race, Himeloch et al (2004) found that 200 US participants with serious mental illnesses had over three times the odds of reporting chronic bronchitis, and over five times the odds of reporting emphysema (Himelhoch et al., 2004). Part of the reason is the higher smoking rates in those with mental illness compared to those without, potentially due to the relaxation effects of smoking for those with anxiety disorders. There is evidence that smoking can temporarily lessen the symptoms of mental illness, however attempts to quit smoking can be a stressor that increases symptoms (Minichino et al., 2013).

The positive relationship between K10 and respiratory symptoms was weaker in those with asthma or COPD. A similar effect was observed where the positive relationship between K10 and respiratory symptoms was weaker in those with a history of mental ill-health. This could indicate that having a prior diagnosis is almost protective at higher levels of distress, as individuals have something which to attribute their respiratory symptoms. Whereas those without a previously existing diagnosis, but experiencing high levels of distress, have no frame of reference, so their higher distress could be associated with more respiratory symptoms.

There was no evidence of Hazelwood mine fire exposure modifying the associations, meaning that highly distressed participants in the non-exposed community were equally likely to report respiratory symptoms, as highly distressed exposed participants in this Survey. There is the possibility that the Adult Survey,
conducted 2.5 to 3 years after the mine fire, missed an earlier period where the mine fire smoke exposure may have modified the association between respiratory and mental health symptoms. The Hazelwood Health Study Hazelinks Stream found an increased risk of accidental-injury-related deaths in the smoke effected region during the mine fire period, and an increased risk of cardiovascular-related deaths during the 6 months immediately after the mine fire (Dimitriadis et al., 2021). Co-occurring respiratory and psychological distress during these periods may have contributed to accidents, and may have been associated with increased inflammation, such as hs-CRP, which in turn is a risk factor for heart disease. Hazelinks reported likely evidence of increased respiratory, cardiovascular and psychological distress during the Hazelwood mine fire exposure period, observing a 25% increase in dispensation of respiratory medications, a 10% increase in cardiovascular medications and a 12% increase in psychiatric medications associated with each 10 μg/m³ increase in mine fire-related PM$_{2.5}$ over a lag range of 3-7 days exposure (Johnson, Dipnall, et al., 2019). Hazelinks also reported a 7% increase in respiratory-related health service use, and a 32% increase in mental health service consultations by men, associated with each 10 μg/m³ increase in mine fire-related PM$_{2.5}$ (Johnson et al., 2020). A study of destructive wildfire effected communities in Spain, showed increased use of anxiolytics-hypnotics, and drugs for obstructive airway diseases, in medium and highly exposed communities compared with unaffected communities, in the 12 months immediately after the fires (Caamano-Isorna et al., 2011). As the interval from the Hazelwood mine fire to the Adult Survey increased, it’s possible that any
modifying effect of the event, on the association between respiratory and mental health, dissipated.

The strengths of this analysis included having an unexposed comparison group who had similar characteristics to the exposed individuals from Morwell, but who were not exposed to the Hazelwood mine fire smoke. This allowed the researchers to investigate whether there was an interaction between exposure, psychological distress and respiratory symptoms. Validated questionnaires were used to assess psychological distress and respiratory symptoms. The analysis also took into consideration potential confounders and effect modifiers, including pre-existing respiratory and/or mental health conditions. The main limitation was the cross-sectional design which meant that the direction of associations was unclear and we could not infer causation. The increased distress may lead to increased respiratory symptoms or the increased respiratory symptoms may lead to increased distress (Simon et al., 2006).

These findings suggest that respiratory symptoms in individuals from communities affected by smoke, such as those affected by the 2020 megafires in western United States, Brazil and Australia, may be exacerbated by increasing distress, or vice versa. This may be regardless of the level of smoke exposure, or the presence of underlying comorbid conditions including COPD, asthma or pre-existing mental health conditions.

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Similarly, these findings may be relevant to the COVID-19 setting where the magnitude, longevity and interrelationship of the respiratory and psychological health sequelae are yet to be fully appreciated (Mukaetova-Ladinska & Kronenberg, 2020). In the first weeks and months of the COVID-19 outbreak, a survey of Chinese respondents without COVID-19 found that average IES-R scores exceeded the usual cut-off for PTSD, and that psychological symptoms were worse in younger compared with older respondents (Wang et al., 2020). Further, very poor rating of health status, history of chronic illness and somatic physical symptoms including cough and breathing difficulty were significantly associated with higher IES-R scores (Wang et al., 2020). In a health record linkage study of almost 70 million patients in the USA, including more than 62 thousand diagnosed with COVID-19, the diagnosis of COVID-19 was associated with approximately twice the incidence of psychiatric diagnosis in the following 14 to 90 days, compared to six control health events (Taquet, Luciano, Geddes, & Harrison, 2021). The most frequent psychiatric diagnosis after COVID-19 diagnosis was anxiety disorder (HRs 1.59–2.62, all p<0.0001), with a probability of outcome within 90 days of 4.7% (95% CI 4.2–5.3) (Taquet et al., 2021). Among anxiety disorders, the most frequent were adjustment disorder, generalised anxiety disorder, post-traumatic stress disorder and panic disorder (Taquet et al., 2021).
This link between respiratory and psychological symptoms highlights that medical professionals need to enquire about psychological symptoms when a patient presents with respiratory symptoms and vice versa. Somatic symptoms, including shortness of breath have diagnostic utility for disorders such as posttraumatic stress disorder (Graham, Searle, Van Hooff, Lawrence-Wood, & McFarlane, 2019). Functional somatic symptoms, including breathlessness are frequently the axis of distress that leads to a person seeking health care (McFarlane, Ellis, Barton, Browne, & Van Hooff, 2008). Allied health professionals such as psychologists and counsellors, should enquire about respiratory health and other somatic symptoms when patients present with mental health symptoms. Pharmacological interventions such as psychotropic medication, and non-pharmacological interventions such as cognitive behavioural therapy or other forms of psychotherapy, could reduce psychological distress and associated respiratory symptoms and improve quality of life (Vu et al., 2020). Antidepressants, for example, are thought to have an anti-inflammatory and anti-oxidative effects (Gałecki, Mossakowska-Wójcik, & Talarowska, 2018). Likewise, use of bronchodilators and other medications, non-invasive ventilation and oxygen therapy to reduce respiratory symptoms, may in turn improve psychological symptoms (Vu et al., 2020).
References


Goodwin, R. D., Jacobi, F., & Thefeld, W. (2003). Mental disorders and asthma in the community. Arch Gen Psychiatry, 60(11), 1125-1130. doi:10.1001/archpsyc.60.11.1125


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StataCorp. (2017). Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.


Table 1. Participants' characteristics including K10 non-specific psychological distress, by respiratory symptoms.

<table>
<thead>
<tr>
<th>Participant characteristic</th>
<th>Total N = 4,056</th>
<th>No respiratory symptoms N=1,229</th>
<th>Any respiratory symptom N=2,827</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (weighted %)</td>
<td>n (weighted %)</td>
<td>n (weighted %)</td>
<td>p-value</td>
</tr>
<tr>
<td>Female</td>
<td>2255 (53%)</td>
<td>651 (50%)</td>
<td>1604 (54%)</td>
</tr>
<tr>
<td>Morwell residents</td>
<td>3096 (68%)</td>
<td>834 (60%)</td>
<td>2262 (73%)</td>
</tr>
<tr>
<td>Employment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paid employment (Full time, Part time, self-employed)</td>
<td>1762 (53%)</td>
<td>595 (59%)</td>
<td>1167 (50%)</td>
</tr>
<tr>
<td>Other (student/volunteer/home-duties/retired)</td>
<td>1799 (36%)</td>
<td>548 (36%)</td>
<td>1251 (36%)</td>
</tr>
<tr>
<td>Unemployed</td>
<td>158 (5%)</td>
<td>31 (3%)</td>
<td>127 (6%)</td>
</tr>
<tr>
<td>Unable to work</td>
<td>283 (6%)</td>
<td>34 (3%)</td>
<td>249 (8%)</td>
</tr>
<tr>
<td>Highest educational qualification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary up to year 10</td>
<td>1247 (25%)</td>
<td>349 (22%)</td>
<td>898 (26%)</td>
</tr>
<tr>
<td>Secondary year 11-12</td>
<td>830 (22%)</td>
<td>265 (24%)</td>
<td>565 (21%)</td>
</tr>
<tr>
<td>Certificate</td>
<td>1375 (37%)</td>
<td>394 (35%)</td>
<td>981 (37%)</td>
</tr>
<tr>
<td>University or other Tertiary degree</td>
<td>552 (16%)</td>
<td>200 (19%)</td>
<td>352 (15%)</td>
</tr>
<tr>
<td>Married/Defacto relationship</td>
<td>2463 (58%)</td>
<td>796 (60%)</td>
<td>1667 (57%)</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>1993 (53%)</td>
<td>725 (64%)</td>
<td>1268 (48%)</td>
</tr>
<tr>
<td>Former smoker</td>
<td>1377 (30%)</td>
<td>372 (26%)</td>
<td>1005 (32%)</td>
</tr>
<tr>
<td>Current smoker</td>
<td>642 (17%)</td>
<td>117 (10%)</td>
<td>525 (20%)</td>
</tr>
<tr>
<td>Occupational exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not exposed</td>
<td>2433 (63%)</td>
<td>788 (67%)</td>
<td>1645 (61%)</td>
</tr>
<tr>
<td>Coal mine/power station exposed</td>
<td>523 (10%)</td>
<td>155 (10%)</td>
<td>368 (11%)</td>
</tr>
<tr>
<td>Exposed, but not coal mine/power station</td>
<td>1100 (26%)</td>
<td>286 (23%)</td>
<td>814 (28%)</td>
</tr>
<tr>
<td>History of asthma and/or COPD</td>
<td>1131 (29%)</td>
<td>91 (8%)</td>
<td>1040 (38%)</td>
</tr>
<tr>
<td>History of mental health conditions</td>
<td>1331 (33%)</td>
<td>235 (20%)</td>
<td>1096 (40%)</td>
</tr>
<tr>
<td>Psychological distress (K10 categories)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2613 (66%)</td>
<td>1021 (85%)</td>
<td>1592 (58%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>628 (16%)</td>
<td>87 (8%)</td>
<td>541 (20%)</td>
</tr>
<tr>
<td>High</td>
<td>380 (10%)</td>
<td>47 (5%)</td>
<td>333 (12%)</td>
</tr>
<tr>
<td>Very high</td>
<td>288 (8%)</td>
<td>24 (2%)</td>
<td>264 (10%)</td>
</tr>
<tr>
<td>Weighted Mean (SD)</td>
<td>Weighted Mean (SD)</td>
<td>Weighted Mean (SD)</td>
<td>p-value</td>
</tr>
<tr>
<td>Age</td>
<td>50.5 (18.9)</td>
<td>50.6 (19.3)</td>
<td>50.4 (18.6)</td>
</tr>
</tbody>
</table>

Abbreviations: COPD = chronic obstructive pulmonary disease; SD = standard deviation; K10 = Kessler 10 item psychological distress scale. Missing data include: 6 records for age, 2 for sex, 54 for employment; 52 for highest educational qualification, 44 for smoking status, 19 for history of mental health condition, and 140 for K10 total score.
Table 2. Weighted mean and SD of K10 total score by self-reported respiratory symptoms and mine fire exposure group

<table>
<thead>
<tr>
<th>Respiratory symptom</th>
<th>Sale N=960</th>
<th></th>
<th>Morwell N=3096</th>
<th></th>
<th>p-value$^+$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No symptoms</td>
<td>With symptoms</td>
<td>No symptoms</td>
<td>With symptoms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K10 weighted Mean (SD)</td>
<td>K10 weighted Mean (SD)</td>
<td>K10 weighted Mean (SD)</td>
<td>K10 weighted Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>Current wheeze</td>
<td>13.32 (4.79)</td>
<td>16.00 (6.68)</td>
<td>14.49 (6.85)</td>
<td>19.55 (9.55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>13.26 (4.70)</td>
<td>17.84 (7.28)</td>
<td>14.89 (7.17)</td>
<td>21.30 (9.67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nocturnal shortness of breath</td>
<td>13.42 (4.53)</td>
<td>18.56 (9.26)</td>
<td>15.28 (7.40)</td>
<td>22.06 (10.19)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Resting shortness of breath</td>
<td>13.41 (4.68)</td>
<td>20.02 (8.80)</td>
<td>15.19 (7.32)</td>
<td>22.25 (10.06)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nasal symptoms</td>
<td>13.15 (5.01)</td>
<td>15.24 (5.79)</td>
<td>14.91 (7.69)</td>
<td>18.34 (8.90)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current nasal symptoms</td>
<td>13.40 (5.29)</td>
<td>15.14 (5.53)</td>
<td>15.06 (7.79)</td>
<td>18.58 (8.91)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nasal &amp; eye symptoms</td>
<td>13.61 (5.34)</td>
<td>15.41 (5.56)</td>
<td>15.49 (7.95)</td>
<td>19.21 (9.08)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic cough</td>
<td>13.39 (4.77)</td>
<td>16.97 (7.57)</td>
<td>15.14 (7.23)</td>
<td>19.98 (10.08)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic phlegm</td>
<td>13.51 (4.86)</td>
<td>16.77 (7.46)</td>
<td>15.20 (7.23)</td>
<td>20.88 (10.32)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Any respiratory symptom</td>
<td>12.45 (4.10)</td>
<td>15.12 (6.06)</td>
<td>12.93 (5.44)</td>
<td>18.01 (9.01)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Abbreviation: K10 = Kessler 10 item psychological distress scale

$^+$One-way ANOVA for difference between 4 weighted means.

Missing data include: 10 records for current wheeze, chest tightness, nocturnal shortness of breath, and 11 records for the remaining respiratory symptoms.
Table 3. Associations between increments in K10 score and respiratory symptoms from univariate and multivariate logistic regressions

<table>
<thead>
<tr>
<th>Respiratory symptom</th>
<th>OR per 5 unit increase in K10</th>
<th>Crude OR (95% CI)</th>
<th>p-value</th>
<th>Adj OR† (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current wheeze</td>
<td></td>
<td>1.51 (1.42,1.61)</td>
<td>&lt;0.001</td>
<td>1.39 (1.30,1.49)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic cough</td>
<td></td>
<td>1.46 (1.39,1.54)</td>
<td>&lt;0.001</td>
<td>1.36 (1.28,1.44)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chronic phlegm</td>
<td></td>
<td>1.48 (1.40,1.57)</td>
<td>&lt;0.001</td>
<td>1.38 (1.30,1.47)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chest tightness</td>
<td></td>
<td>1.59 (1.50,1.68)</td>
<td>&lt;0.001</td>
<td>1.46 (1.37,1.55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nocturnal shortness of breath</td>
<td></td>
<td>1.57 (1.49,1.67)</td>
<td>&lt;0.001</td>
<td>1.47 (1.37,1.58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Resting shortness of breath</td>
<td></td>
<td>1.64 (1.54,1.74)</td>
<td>&lt;0.001</td>
<td>1.48 (1.38,1.59)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current nasal symptoms</td>
<td></td>
<td>1.31 (1.24,1.39)</td>
<td>&lt;0.001</td>
<td>1.21 (1.14,1.28)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current nasal &amp; eye symptoms</td>
<td></td>
<td>1.30 (1.23,1.37)</td>
<td>&lt;0.001</td>
<td>1.23 (1.16,1.31)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Abbreviations: OR = odds ratio; CI = confidence interval; Adj OR = adjusted odds ratio; K10 = Kessler 10 item psychological distress scale

† OR adjusted for exposure (Morwell vs. Sale), age, gender, employment, education, marital status, smoking, occupational exposures, and pre-existing respiratory and mental health conditions.
Figure 1. Associations between respiratory outcomes and 5 unit increases in K10. 
Note: The dotted line indicates an OR of 1.0 representing no association. Interaction model p values are presented as * p<0.05; ** p<0.01 *** p<0.001 for the interaction term.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Exposure interaction models</th>
<th>Asthma/COPD interaction models</th>
<th>Mental health interaction models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current wheeze</td>
<td>1.42 (1.32, 1.53)</td>
<td>1.31 (1.17, 1.48)</td>
<td>1.27 (1.17, 1.38)</td>
</tr>
<tr>
<td>Chronic cough</td>
<td>1.30 (1.11, 1.52)</td>
<td>1.42 (1.32, 1.54)</td>
<td>1.67 (1.41, 1.94)</td>
</tr>
<tr>
<td>Chronic phlegs</td>
<td>1.35 (1.27, 1.44)</td>
<td>1.44 (1.34, 1.55)</td>
<td>1.31 (1.21, 1.43)</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>1.37 (1.18, 1.60)</td>
<td>1.42 (1.33, 1.53)</td>
<td>1.42 (1.30, 1.55)</td>
</tr>
<tr>
<td>Nocturnal shortness of breath</td>
<td>1.30 (1.11, 1.52)</td>
<td>1.49 (1.30, 1.70)</td>
<td>1.33 (1.23, 1.44)</td>
</tr>
<tr>
<td>Resting shortness of breath</td>
<td>1.37 (1.18, 1.58)</td>
<td>1.38 (1.28, 1.50)</td>
<td>1.28 (1.18, 1.38)</td>
</tr>
<tr>
<td>Current nasal symptoms</td>
<td>1.46 (1.35, 1.57)</td>
<td>1.48 (1.38, 1.60)</td>
<td>1.44 (1.31, 1.59)</td>
</tr>
<tr>
<td>Current nasal &amp; eye symptoms</td>
<td>1.49 (1.37, 1.68)</td>
<td>1.49 (1.38, 1.60)</td>
<td>1.29 (1.18, 1.38)</td>
</tr>
</tbody>
</table>

Odds Ratio per 5 unit increase in K10 (95% Confidence Interval)

- See: No Asthma/COPD, no mental health history
- No: Asthma/COPD, no mental health history
- Morwell: Asthma/COPD
- History of mental health

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Author/s:

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