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Review

# Mental health impacts of environmental exposures: A scoping review of evaluative instruments

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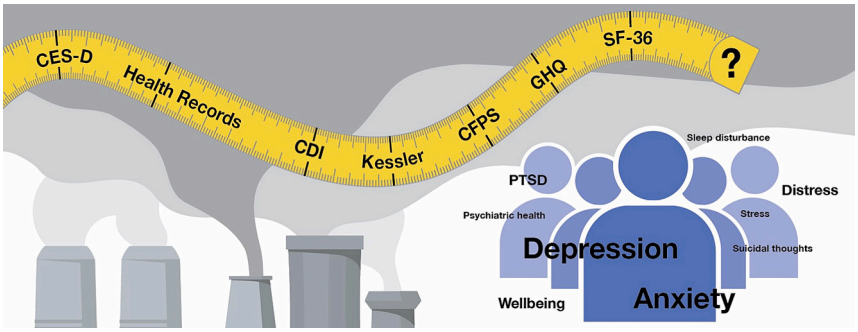
## HIGHLIGHTS

- Environmental exposures have adverse impacts on psychological health.
- International research has acknowledged psychological harms from environmental exposures.
- There is no uniform approach to measure psychological impacts from environmental pollution.

## GRAPHICAL ABSTRACT

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## ABSTRACT

To date, much of the health focus of environmental policy has been on preventing physical health impacts of environmental exposures. Recent research has however highlighted increasingly concurrent mental health effects and its consideration is an emerging requirement for many governments and their agencies, yet there are limited universal mental health assessment tools for environmental exposures.

This paper details the findings of a scoping review that evaluated assessment tools used to measure psychological impacts from environmental exposures and pollution, as reported in recent peer-reviewed literature (2000−2022). Across the 126 papers identified in our review, a wide range of tools to assess mental health impact were identified. We document a clear recent upswing of research interest in the mental and psychological impacts of environmental exposures, and an overarching concern for air pollution from industry, traffic, and fires. A majority of studies utilised standardised assessment instruments, but there was little consistency in the way that these were combined or deployed. The dominant mental health outcomes of interest in these studies were depression, anxiety, and mental and psychiatric health. The findings of the review identify a need and opportunity to develop a best-practice approach to consistently assess the mental health impacts arising from environmental exposures.

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Future work is needed to define the most appropriate choice and application of assessment tools to evaluate adverse mental health impacts from environmental exposures. This will support a more universal, coordinated and cross-jurisdiction approach for the assessment, quantification and targeted response to addressing mental health impacts arising from environmental exposures.

## 1. Introduction

The notion that the quality of our physical environment affects our mental health is not new. This has been identified in numerous studies describing positive mental health impacts that arise from access to green space (i.e. areas with plants and natural features) and blue space (areas containing water bodies, such as lakes, rivers, canals, and beaches) (Dzhambov et al., 2019; McDougall et al., 2022). There has also been a notable recent increase in research demonstrating the relationship between environmental exposures and adverse impacts upon mental health. For example, in the USA Adkins et al. (2022) linked fluoride exposure to anxiety and depression; in Australia Ahmed et al. (2022) linked air pollution exposure to mental health outcomes; and in China Deng et al. (2022) presented evidence linking household cooking pollution to anxiety and depression in older adults. In addition, there is a body of work that builds upon our knowledge of the causal pathways linking environmental exposures to mental and physical effects (for example Markevych et al. (2017)). Furthermore, recent research has demonstrated that high levels of stress and anxiety, for example, can lead to physical health effects such as lowered immune system response, creating increased vulnerability to illness and disease (Alderman et al., 2012; Simpson et al., 2011).

In parallel, and no doubt related to the documented increase in research focussed on the psychological effects of environmental exposures, environmental policy has also shifted in its focus. Until recently much of the environmental policy focus has largely rested on preventing physical health impacts of environmental exposure including respiratory and cardiac disease, and cancer (Australian Government, 2022; European Environment Agency, 2022; US EPA, 2022). Consideration of mental health (also referred to in the policy context as psychological health, cf. Harvey et al., 2014) is emerging as an additional requirement for many governments and their agencies to measure and assess following environmental exposures.

For example, the Environment Protection Act 2017 (Victorian Government, 2023) defines human health as including 'psychological health'. Yet there is no policy or practical precedent for how the Environment Protection Authority Victoria, which exists under this act, to either measure psychological health impacts from pollution or protect against them. Moreover, there are currently no standardised methods to measure community mental health in the context of environment pollution harms. Therefore, there is a significant research gap, which this review addresses, to determine available resources currently used to measure the impact of pollution on mental health.

In a recent case (Supreme Court of Victoria, 2020), evidence given for psychological harm by smoke from a mine fire included victim impact statements and expert witness reports that such an incident may cause harm. Having an objective tool to measure psychological impact would be an asset in such cases, as well as in the regulation of polluting industries. A standardised tool to compare impacts from different events or in different locations would be invaluable enable environmental and health agencies to make better and more informed choices. Hence, it is important to understand what tools are currently available and how they have been applied to pollutant exposures.

Heightened interest in the psychological health impacts of environmental exposures indicates there is an increased need for best-practice measurement of mental health impacts in this context. Therefore, the aim of this study, is to systematically review the peer-reviewed evidence to identify the suite of tools that have been used to measure the psychological health impacts of environmental pollution exposures. The following section describes our analysis and the scoping model of a systematic review (scoping review) approach used. We then summarise the results of the review and reflect on the priorities for the development of assessment tools to support future policy responses.

The research question the review sought to answer was: 'What assessment tools are used to measure human psychological health outcomes from exposure to environmental pollution?'

Here we are primarily interested in population-level impacts, as per the predominant focus of environment protection agencies. Specifically, this paper considers the primary instruments that have been used to measure mental health impacts from environmental exposures, what sort of impacts were identified, and any implications for their use in a regulatory context.

## 2. Methods and approach

To explore contributions to the international academic literature that describe assessment tools to capture and assess the mental health impacts on people from environmental pollution exposures in the 21st century, we undertook a scoping review, in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). A scoping review provides an overview of a vast topic (Moher et al., 2015), and is a suitable approach for exploring a body of literature and identifying gaps in the field (Munn et al., 2018a). Our review was conducted in core stages based on Arksey and O'Malley's (2005) influential 5-step framework for scoping reviews. This method can be seen as an overall study protocol including identification of search terms and selection of databases in which to search. This scoping review conforms to the PRISMA-ScR guidelines, and a completed checklist has been provided. Protocol registration (for example via Prospero) was not available due to the focus on *tools* to assess health impacts.

### 2.1. Identifying the review scope

Given the breadth of our topic, and the scope for potential research questions, a series of three workshop meetings were held with all authors to develop key research themes and framing for a scoping review. All authors guided the themes in terms of framing them as main components of our scoping review (see Supplementary Table S1).

The disciplinary diversity of the team (including housing research, urban geography, environmental health, and social epidemiology) enabled the exploration and development of well-considered research themes from a contextual lens of environmentally-associated mental health evaluation tools. This was an iterative process where search terms under each of the themes were discussed, reviewed and added (see Supplementary Table S2).

We define an assessment tool as a packaged set of questions used to measure the mental health of an individual in association with or as a consequence of an environmental exposure, irrespective of whether identifying mental health was the focus of the study. We used three key themes to guide the search: environmental exposures, psychological health outcomes, and measurement tools. These were framed for scoping review purposes as topic main components using the well-accepted Population, Concept and Context (PCC) mnemonic (Peters et al., 2020). Our PCC application is shown in Supplementary Table S1. This ensured inclusion of assessment tools utlized around the globe (Munn et al., 2018b; Peters et al., 2020). Our review included studies across a broad population of countries, internationally.

### 2.2. Identifying relevant studies: eligibility criteria, information sources and searches

The review was based on literature published from 1 January 2000 to 30 June 2022 to capture recent contributions to the study enquiry. Three key databases were used: Scopus, Embase and Web of Science. These were selected to reflect the scope of our topic across social fields, and the range of disciplines publishing in these fields. Databases were searched using text words. Following an initial search in Scopus in early June of 2022 that identified 91,484 results, the final database searches were conducted later that month (see Supplementary Table S3). Reference lists from the retrieved articles were reviewed for possible articles to be included.

The PCC approach ensured consistency between our research question and eligibility criteria. Filtering methods included the publication date range from 1 January 2000 to 30 June 2022, published in the English-language, and excluding grey-literature. Although the grey literature has covered our study enquiry (Piggot-McKellar et al., 2019), there is a lack methodological guidance on the inclusion of grey literature for scoping studies (Tricco et al., 2016). Articles were included if they measured the mental health outcomes or psychological impacts in association with environmental exposures. Articles that only measured physical health impacts or that did not use a measurement tool were excluded (Fig. 1). The search returned numerous articles that focussed only on the impacts of an environmental disaster, but not the impacts of pollutants resulting from the disaster. A large number of these related to flood events. For this reason, 'flood' was excluded from search criteria, with relevant pollutant impacts still captured by the remaining contaminant/pollution search terms. Many laboratory experiments involving animals were also captured in the initial search, which were not of relevance here and were excluded.

### 2.3. Study selection

The initial search returned 1296 articles, from which 749 duplicates were removed. The first round of screening (title and abstracts) was used to exclude articles that did not address our research question. Data cleaning was completed independently by authors CM and CB. Exclusions were discussed with the wider research team, who guided the screening process. The second round of screening (full text) was completed by CM and CB independently. Each article was selected based on eligibility criteria (as outlined in Section 2.2). To ensure consistency of the selection across all reviewers, EB independently assessed the level 2 screening decisions. The final screening identified 126 papers for inclusion in our review. Fig. 1 presents an overview of the article selection. Search terms used are listed in Supplementary Tables S2 and S3.

### 2.4. Data extraction

The included articles were tabulated and data extracted into a spreadsheet and organized in alphabetical order. Descriptive characteristics of the studies were tabulated and detailed in the form of an

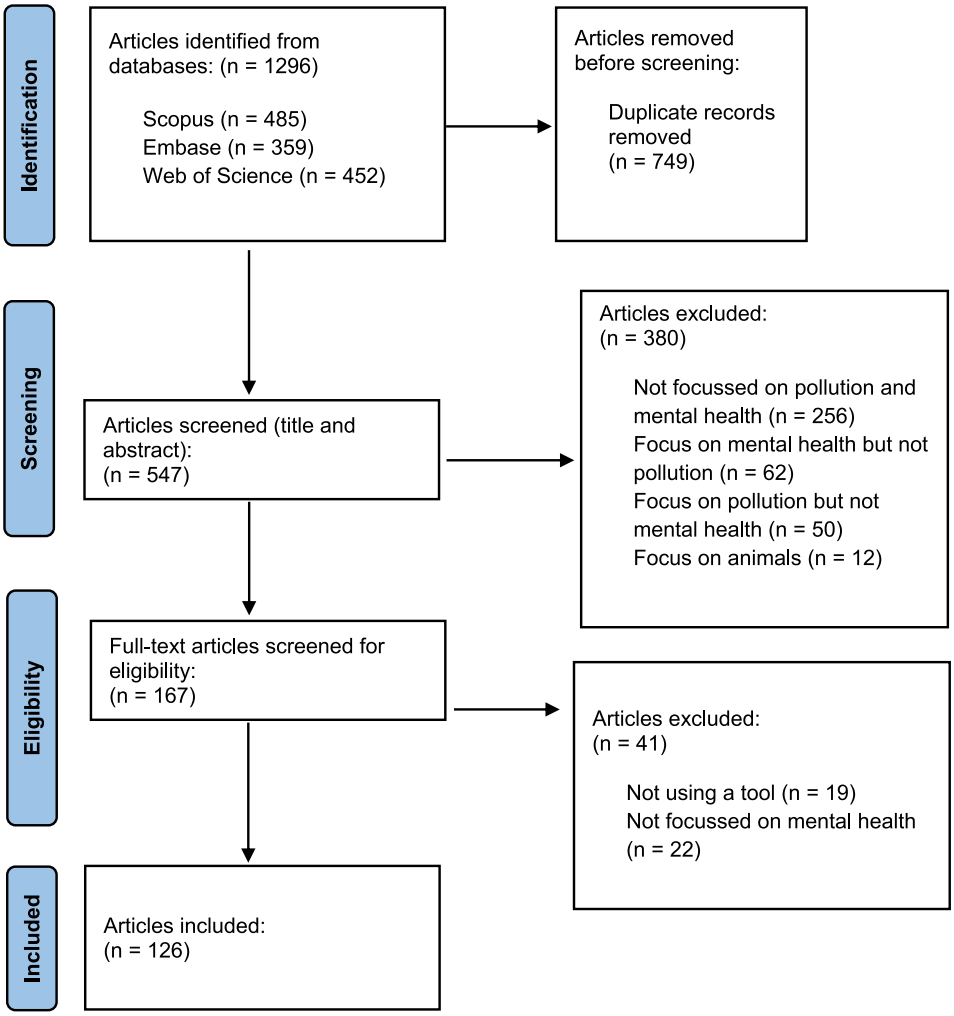


**Fig. 1.** PRISMA flowchart depicting the article search, review and selection process.

annotated bibliography, as: the authorship, title, study location, exposure of focus, if association was measured, psychological health outcome of focus, study sample size, and type of psychological health measurement tool used (see Supplementary Table S4). The purpose here was not to review the included articles, but instead to determine which data to extract based on the agreed criteria (as outlined in Section 2.2).

The primary aim was to determine whether studies used evaluative instruments to measure mental health impacts of environmental exposures, followed by ensuring each study related to the main components of research question (as outlined in Section 2.1). Our focus was not to explore all potential psychological impacts of environmental exposures, but rather to scope tools to assess mental health outcomes of environmental exposures. Data extraction was undertaken by CM and checked by EM and CB to ensure comprehensive relevant extraction and organization within the descriptive characteristic.

### 2.5. Data analysis

Data analysis was undertaken by three team members (CM, EB, CB), each concentrating on a descriptive aspect closely related to their own area of expertise (e.g. housing, health, environment). The three members discussed the descriptors and findings across studies.

## 3. Results

Mental health impacts of environmental exposures have been considered intermittently throughout the period 2000–2022. As shown in Fig. 2, the number of studies measuring the association of pollution with mental health impacts has increased dramatically in recent years (detailed in Supplementary Table S4). Concomitently, there has been increasing global interest in mental health. For example, the Organization for Economic Cooperation and Development (OECD, 2023) has recommended the integration of mental health, education, workplace and social protection policies. There is recognition that the health system alone cannot remedy mental health issues, with intervention, support and provision of services needing to be addressed across all areas of government policy (OECD, 2023).

Of the 126 papers identified in the review, the majority (87 %, 110 studies) reported an association between environmental exposure and psychological health outcomes. Two studies found that people's perception of their exposure was more strongly associated with adverse impacts than actual exposure. Thirteen studies (10 %) did not find a statistically significant association with mental health. A further three studies (2 %) did not state clearly whether mental health impact was identified from the research.

The majority of studies were conducted in Asia ($n = 56$), namely China ($n = 31$), where the primary concern was the role of air pollution on mental health (Fig. 3). These focussed on fine particles ($PM_{2.5}$) in particular (e.g., (Wang et al., 2020; Xue et al., 2021)), but also other air pollutants such as coarse particles ($PM_{10}$), nitrogen oxides ($NO_x$), sulphur dioxide ($SO_2$) (Zu et al., 2020), carbon monoxide (CO) (Qiu et al., 2022) and ozone ($O_3$) (Ma et al., 2022). There were 31 studies from Europe and 24 from the United States that assessed specifically mental health and its relationship to pollution events. Many ($n = 16$) of the USA studies also considered air pollution (e.g., Pagliaccio et al. (2020); Thilakaratne et al. (2020)), including wildfire smoke (Humphreys et al., 2022) and traffic pollutants (Yolton et al., 2019), and a smaller proportion ($n = 5$) considered water contamination (Kruger et al., 2017; Muhammad et al., 2018), odour (Behbod et al., 2014), general pollutant release from industry (Downey and Van Willigen,

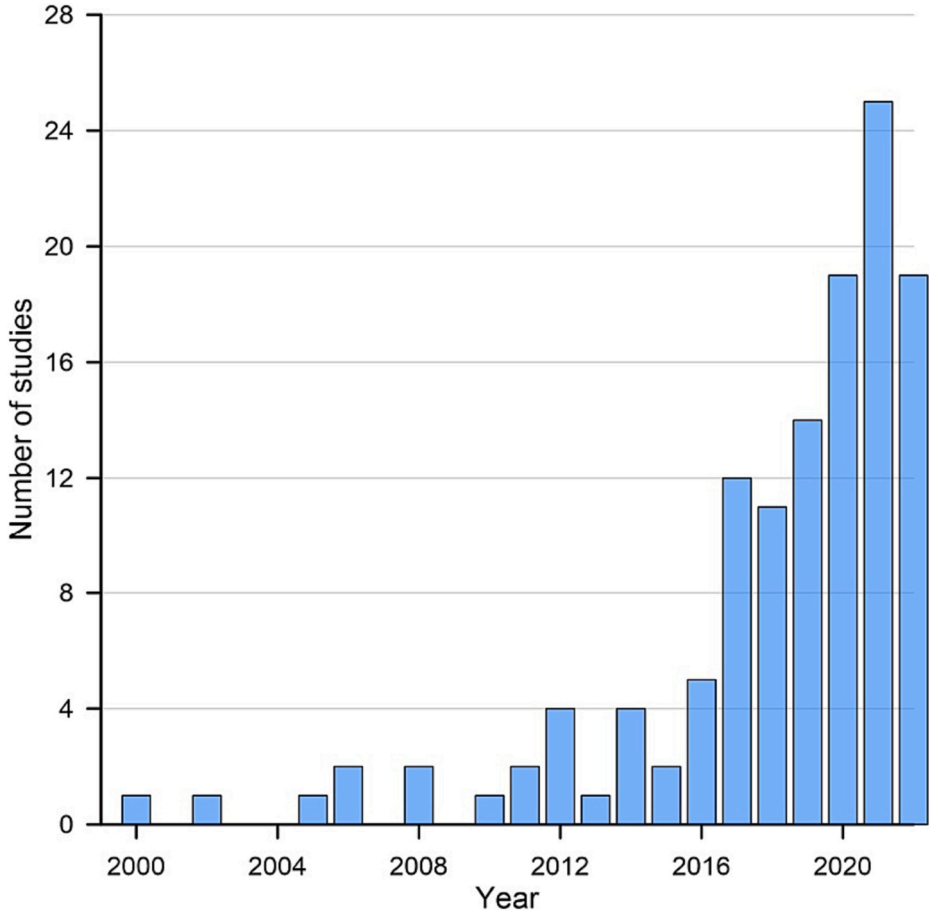


**Fig. 2.** Number of studies examining both mental health impacts of environmental exposures, identified by year for the period 2000–2022.

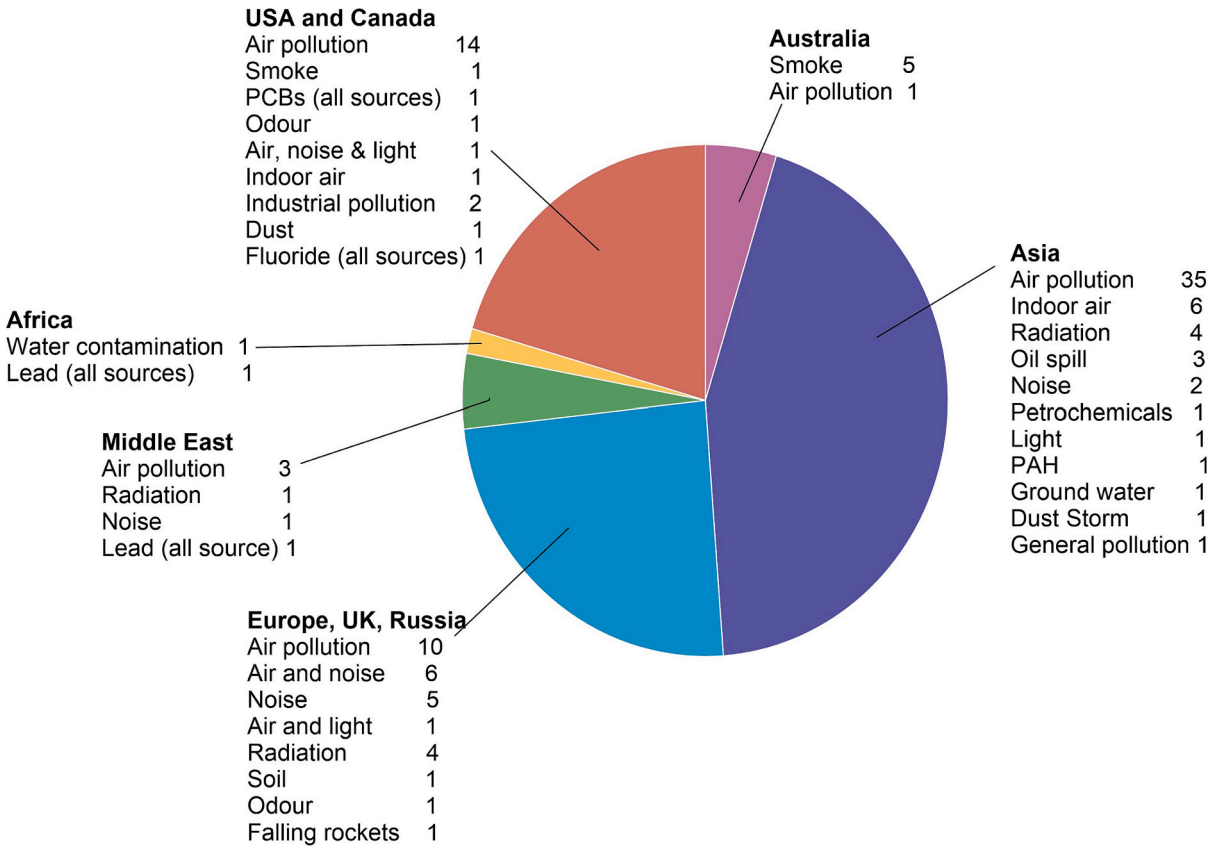


**Fig. 3.** Global distribution of studies assessing mental health and the associated pollution source of interest.

2005; Sansom et al., 2017) and indoor air quality (Rickenbacker et al., 2020). Apart from South Korea (11 studies), Australia (6) and Japan (6), the remaining studies were scattered across the world. The international coverage of studies suggests global interest in the impacts of environmental exposures and pollution on mental health, and the extent of emerging concern. Some countries had a particular focus in their studies, such as air pollutants in China, radiation in the Ukraine (Adams et al., 2011; Bromet, 2012) and Japan (Goto et al., 2019; Hori et al., 2016), and wildfire (Rodney et al., 2021) and coal mine fire (Carroll et al., 2022) air pollutants in Australia.

Of the 126 studies reviewed that examined the nexus between mental health and pollution, most (29 %) were focussed on the general population (for example Jung et al. (2019); working-aged or older adults (21 %; e.g. Firdaus (2017). A number of studies (13 %) recruited participants because of known prior exposure (e.g. former Chernobyl residents (Remennick, 2002); engagement with health care services, such as hospital emergency departments (12 %, as in Thilakaratne et al. (2020)). A small number (three studies) focussed on indigenous communities, or migrants communities (Santiago-Rivera et al., 2007). Twelve studies (10 %) focussed specifically on child cohorts (e.g., Yolton et al. (2019)), pregnant women or new mothers (7 %) (such as, Goto et al. (2017)), and a relatively small proportion of studies (6 %) sampled young adults (Zu et al., 2020). On a global scale, air pollution was the most frequently studied contaminant (Fig. 3), namely particulate matter. Air pollution studies were also often combined with noise and light pollution studies.

Mental health-related outcome measures varied, but most studies examined depression (e.g., Yang et al. (2021); Zijlema et al. (2016)) and anxiety (e.g., Lan et al. (2022); Ma et al. (2022)) (Table 1). A significant proportion (8 %) of the identified studies also considered post-traumatic stress disorder (PTSD), (e.g., An Han et al. (2020); Choi et al. (2021)) and suicidal thoughts (Lee et al., 2019). Many of the studies established an association between environmental exposure to pollution and diagnosed mental health problems. There was mixed evidence of negative effects in studies that included mental illness including bipolar and schizophrenia (Aschengrau et al., 2012; Hao et al., 2022; Nguyen et al., 2021; Qiu et al., 2022; Thilakaratne et al., 2020; Yackerson et al., 2014), likely because any exposure may exacerbate underlying health conditions associated with environmental stress.

**Table 1**
Summary of mental health foci of the 126 studies evaluated in this review.

| Mental health measure | Number of studies identified[a] |
|---|---|
| Depression | 59 |
| Anxiety | 30 |
| Mental health | 30 |
| Psychiatric health | 15 |
| Stress | 12 |
| Distress | 13 |
| PTSD | 10 |
| Suicidal thoughts | 10 |
| Sleep disturbance | 7 |
| Wellbeing | 7 |
| Schizophrenia | 5 |
| Substance abuse | 4 |
| Trauma | 4 |
| Bipolar | 4 |
| Hospital admission | 3 |
| Somatisation | 3 |
| Irritability | 2 |
| Confidence | 2 |
| Powerlessness | 2 |
| Concentration | 1 |
| Agitation | 1 |

[a] Note: some studies contain multiple mental health foci.

## 4. Tools, evaluation approaches and methods

Among standardised health scales, the most commonly applied was the USA-developed Centre for Epidemiological Studies-Depression (CES-D); used mainly in studies based in China (Wang et al., 2019; Zhang et al., 2017). Here we define standardised tools as questionnaires that are named and have been developed and tested prior to the study cited, having also been used in previous studies. By comparison, non-standardised tools may be questionnaires, or alternate methods, that are unique to the study cited. Seven studies used the 36-question short form (SF-36, e.g., Cerletti et al. (2020); Gao et al. (2020)) and three used the Kessler tool (Klompmaker et al., 2019; Maybery et al., 2020; Thomson et al., 2020). Both of these assessment tools are utilised commonly for mental health assessment in multiple countries (e.g. (Dahlgren et al., 2022; González-Blanch et al., 2018; Smout, 2019). Studies using standardised scales provided moderate evidence of a negative mental health effect from population exposure. For example, mixed outcomes were reported for studies using SF-36: an association was reported for noise and depression (Eze et al., 2020), noise and stress (Al-Mutairi et al., 2011) and lead contamination and psychiatric disorders (Salehzadeh et al., 2019). Other studies did not find clear association (air and light pollution (Gao et al., 2020); photochemical oxidants (Yamazaki et al., 2006) and noise (Cerletti et al., 2020).

Assessment tools specific to the measurement of mental health impacts from environmental pollutant exposure were not readily evident among the studies reviewed (Table 2). As described above, many employed validated measures of mental health outcomes (e.g. CES—D, e.g. Ao et al. (2021)). Exposure and outcome measures appear to be largely dictated by the specific research design as opposed to representing a particular standardised assessment tool for quantifying the impacts of pollution on community' mental health.

Standardised assessment tools (such as the CES-D, SF-36 and general health questionniare (GHQ) were the most dominant category (includes all 'named' tools in Table 2), comprising 57 % of the studies included in the review. Studies that were based on self-reports comprised just under a quarter of the review (22 %, for example Rajper et al. (2018); see supplementary Table S4). Just over 15 % of the identified studies were based on secondary data (as in the example of Yuan et al. (2020)).

In terms of statistical analysis to determine the strength of the relationship between mental health and pollution, methods were less varied. Most analyses in the identified studies relied upon basic models, for example linear (Gignac et al., 2022), logistic (Goto et al., 2017) or multivariate (Hautekiet et al., 2022) regression, to test for associations between the pollution-related exposure variable and mental health focussed outcome variables. Some improved upon basic models by using (mainly hierarchical) multilevel regression models (Ma et al., 2018). A smaller proportion of studies used models capable of supporting causal inference to analyse panel data, including fixed-, random- and mixed-effects models (e.g. Tjalvin et al. (2017)). A similar proportion employed specialist regression approaches such as Poisson (Thilakaratne et al., 2020) and Tobit (Tian et al., 2015) to account for non-normally distributed variables. Many studies applied paired regression analyses with descriptive statistics, including tests for similarity between cohort outcomes (e.g. using *t*-tests or Chi Squared test, e.g. Zu et al. (2020)). A few studies employed thematic approaches to analyse qualitative data (e.g. Humphreys et al. (2022)).

**Table 2**
Summary of measurement tools identified in this scoping review of those used to assess mental health impacts of environmental exposures.

| Tool | Number of studies identified in review |
|---|---|
| Public health records | 21 |
| CES-D (Center for Epidemiological Studies-Depression) | 15 |
| SF-36 (36-question short form) | 7 |
| Diagnosis | 6 |
| GHQ (General health questionnaire) | 5 |
| SF-12 (12-question short form) | 3 |
| Kessler psychological distress scale | 3 |
| PHQ (Patient health questionnaire) | 3 |
| CDI (Children's depression inventory) | 2 |
| Medication | 2 |
| Trajectory analysis | 1 |
| Other standardised survey/tool | 31 |
| Other (non-standardised) survey | 21 |

## 5. Discussion

We were guided in this review by a relatively simple question: 'What assessment tools are used to measure human psychological health outcomes from exposure to environmental pollution?' Reflecting on the body of work identified, a series of insights much broader than a simple list of assessment tools were obtained.

Firstly, our review suggests a recent, rapid increase in research momentum examining the mental health effects of environmental exposures. The results indicate that the evidence base is dominated by responsive evaluations – shaped by the need to react to specific disasters, such as natural events (e.g wildfires in the USA (Humphreys et al., 2022) and Australia Rodney et al. (2021)) or large-scale pollution events, such as radiation exposure in Ukraine (Adams et al., 2011) and Japan (Goto et al., 2019). The dominance of responsive evaluations in the evidence base is important to acknowledge. While it may often be a feature of a productive reaction to natural experiments and events, the current momentum in the field suggests the need for overarching research that consolidates, and guides the field and its practice towards a more standardised approach.

Reflecting on the assessment tools themselves, the majority of studies applied standardised assessment tools (e.g. Kessler (Maybery et al., 2020), SF-36 (Nakao et al., 2016) and CES-D (Pun et al., 2017)). Although these are powerful in their potential to be applied in different contexts and provide useful baseline and comparison data, there was still a wide diversity of standardised tools applied. Many studies also applied non-standardised assessment tools, such as public health record analysis and medical diagnosis records. A number of standardised tools were applied across different national contexts (for example the CES-D has been used in United States and China based studies). This provides promising cross-national comparability of findings and potential for the formation of global best-practice policy development and practice.

Looking across the included studies, some generalised insights can also be gained on the psychological effects of exposure to environmental exposures and pollution. Firstly, a number of studies (Cerletti et al., 2020; Cuthbertson et al., 2016) demonstrated that individuals who considered themselves to be subject to environmental pollution and harm had adverse mental health outcomes, regardless of the actual measured level of pollution. This is in line with the American Psychological Society's (2017) assertion that people may be adversely affected by fears about their own vulnerability, whether or not these fears are founded. This additionally aligns with evidence that environmental annoyance significantly increased the prediction of psychological symptoms (Azhdari et al., 2022) and shows that where there is a perception of harm, the perception as well as the harm, needs to be addressed. The importance of 'perception of harm' is increasingly highlighted across diverse literatures (see Clayton, 2021), and this is clearly a consideration for future work. Relatedly, while the review was focussed on studies that measured the effects of environmental pollution exposures, it is important to note an increasing acknowledgment of the pernicious effects of ubiquitous or low level exposures to pollutants, such as lead and $PM_{2.5}$ (as for example described in Lanphear, 2017).

Finally, it is important to note that many of the studies identified in this review evaluated the mental health of people who had experienced environmental exposures, but also experienced other concurrent stressors. For example, evacuation related to a nuclear radiation leak

(Adams et al., 2011; Bromet et al., 2000) or a bushfire (Halcomb et al., 2022). This underlies the pragmatic complexity of capturing and responding to the psychological health effects of environmental exposures — people must deal with the effects of environmental exposure and other stressors concurrently. Not only do people experience concurrent stressors, but we also acknowledge the tipping point.

## 6. Limitations

We note that studies describing tools to assess the mental health impacts of pollution were relatively scarce given the broad range of pollutants and of potential psychological impacts. Nevertheless, the studies identified in this review present a broad and heterogenous collection of tools that have been used to assess psychological impacts from exposure to environmental pollution.

The focus of this scoping review was specifically on *tools* to *capture* the mental health impacts of environmental pollution on populations, rather than to evaluate the impacts themselves, or the mechanism of impact. It was therefore not an analysis of the effectiveness of each tool *per se*, but rather a scoping study to investigate what tools have been applied in the context of psychological harms and its association with environmental pollution events. Further research into the strength of associations gained using different tools is warranted. It is also important to investigate the specific mechanism of psychological impact, which was beyond the scope of this review. Relatedly, the defined focus of this review means that there will necessarily be some mental health assessment tools which fell outside of the scoping review parameters (for example in Cao et al., 2023). Consenquently, it is possible that the most effective tool for assessing the mental health impacts of pollution has not yet been applied to the problem. Indeed, separate tools may be required for different environmental contexts. Further research is required to determine which tool would be best in a regulatory context, noting that to evaluate the impacts of different pollutants and different psychological conditions, use of more than one tool may be necessary.

## 7. Conclusion

This scoping review identified 126 studies over the period between January 2000 to June 2022 that examined mental health impacts of environmental exposures. Moreover, the review showed that the number of studies increased significantly over the last decade, reflecting a wider understanding and acceptance that environmental exposures and pollution events have an adverse impact on psychological health.

The review revealed assessment tools used for measuring mental health impacts of environmental pollution and exposures are highly varied in their contruction and what they measure, making comparisons difficult. Consequently, there is a practical gap in selecting and identifying an appropriate tool(s) to support good mental health in environmentally impacted communities in a nationally or internationally consistent manner.

Finally, this review highlights the need for further work on concurrent environmental events and adverse mental health effects to better protect vulnerable communities. Given the rapidly changing environmental and climate boundaries, coupled to a deeper understanding of psychological harms arising from environmental pollution and exposures, the often unseen and pernicious costly mental health impacts need to be addressed to ensure society is better prepared.

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## CRediT authorship contribution statement

**Emma Baker:** Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Cynthia Faye Barlow:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Lyrian Daniel:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Claire Morey:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Rebecca Bentley:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Mark Patrick Taylor:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Emma Baker reports financial support was provided by The University of Adelaide. Mark Patrick Taylor reports financial support was provided by EPA Victoria.

## Data availability

No data was used for the research described in the article.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2023.169063.

## References

Adams, R.E., Guey, L.T., Gluzman, S.F., Bromet, E.J., 2011. Psychological well-being and risk perceptions of mothers in Kyiv, Ukraine, 19 years after the Chornobyl disaster. Int. J. Soc. Psychiatry 57, 637–645.

Adkins, E.A., Yolton, K., Strawn, J.R., Lippert, F., Ryan, P.H., Brunst, K.J., 2022. Fluoride exposure during early adolescence and its association with internalizing symptoms. Environ. Res. 204, 112296 https://doi.org/10.1016/j.envres.2021.112296.

Ahmed, S.M., Mishra, G.D., Moss, K.M., Yang, I.A., Lycett, K., Knibbs, L.D., 2022. Maternal and childhood ambient air pollution exposure and mental health symptoms and psychomotor development in children: An Australian population-based longitudinal study. Environ. Int. 158, 107003 https://doi.org/10.1016/j.envint.2021.107003.

Alderman, K., Turner, L.R., Tong, S., 2012. Floods and human health: a systematic review. Environ. Int. 47, 37–47. https://doi.org/10.1016/j.envint.2012.06.003.

Al-Mutairi, N., Al-Attar, M., Al-Rukaibi, F., 2011. Traffic-generated noise pollution: exposure of road users and populations in Metropolitan Kuwait. Environ. Monit. Assess. 183, 65–75. https://doi.org/10.1007/s10661-011-1906-0.

American Psychological Society, 2017. Mental health and our changing climate. Available at. https://www.apa.org/news/press/releases/2017/03/mental-health-climate.pdf (Accessed 27 October 2022).

An Han, H., Han, I., McCurdy, S., Whitworth, K., Delclos, G., Rammah, A., Symanski, E., 2020. The intercontinental terminals chemical fire study: a rapid response to an industrial disaster to address resident concerns in Deer Park, Texas. Int. J. Environ. Res. Public Health 17, 986. https://doi.org/10.3390/ijerph17030986.

Ao, C.-K., Dong, Y., Kuo, P.-F., 2021. Industrialization, indoor and ambient air quality, and elderly mental health. China Econ. Rev. 69, 101676 https://doi.org/10.1016/j.chieco.2021.101676.

Arksey, H., O'Malley, L., 2005. Scoping studies: towards a methodological framework. Int. J. Soc. Res. Methodol. 8 (1), 19–32. https://doi.org/10.1080/1364557032000119616.

Aschengrau, A., Weinberg, J.M., Janulewicz, P.A., Romano, M.E., Gallagher, L.G., Winter, M.R., Martin, B.R., Vieira, V.M., Webster, T.F., White, R.F., Ozonoff, D.M., 2012. Occurrence of mental illness following prenatal and early childhood exposure to tetrachloroethylene (PCE)-contaminated drinking water: a retrospective cohort study. Environ. Health 11. https://doi.org/10.1186/1476-069x-11-2.

Australian Government, 2022. Australia State of the Environment Report 2021. Available at. https://soe.dcceew.gov.au/ (Accessed 28 November 2022).

Azhdari, S.S., Yunesian, M., Hassanvand, M.S., Nodehi, R.N., Darvishali, S., Faridi, S., Shamsipour, M., 2022. Associations of combined short-term exposures to ambient PM2.5 air pollution and noise annoyance on mental health disorders: a panel study of healthy college students in Tehran. Air Qual. Atmos. Health 15, 1497–1505. https://doi.org/10.1007/s11869-022-01199-8.

Behbod, B., Parker, E.M., Jones, E.A., Bayleyegn, T., Guarisco, J., Morrison, M., McIntyre, M.G., Knight, M., Eichold, B., Yip, F., 2014. Community health assessment following mercaptan spill: Eight Mile, Mobile County, Alabama, September 2012.

J. Public Health Manag. Pract. 20, 632–639. https://doi.org/10.1097/PHH.0000000000000024.
Bromet, E.J., 2012. Mental health consequences of the Chernobyl disaster. J. Radiol. Prot. 32, N71–N75. https://doi.org/10.1088/0952-4746/32/1/n71.
Bromet, E.J., Goldgaber, D., Carlson, G., Panina, N., Golovakha, E., Gluzman, S.F., Gilbert, T., Gluzman, D., Lyubsky, S., Schwartz, J.E., 2000. Children's well-being 11 years after the Chornobyl catastrophe. Arch. Gen. Psychiatry 57, 563–571. https://doi.org/10.1001/archpsyc.57.6.563.
Cao, C.H., Liao, X.L., Jiang, X.Y., Li, X.D., Chen, I.H., Lin, C.Y., 2023. Psychometric evaluation of the depression, anxiety, and stress scale-21 (DASS-21) among Chinese primary and middle school teachers. BMC Psychol. 11 (1), 209.
Carroll, M., Campbell, T.C.H., Smith, C.L., Gao, C.X., Maybery, D., Berger, E., Brown, D., Allgood, S., Broder, J.C., Ikin, J., McFarlane, A., Sim, M.R., Walker, J., Abramson, M. J., 2022. An exploration of the trajectory of psychological distress associated with exposure to smoke during the 2014 Hazelwood coal mine fire. Int. J. Hyg. Environ. Health 241, 113946. https://doi.org/10.1016/j.ijheh.2022.113946.
Cerletti, P., Eze, I.C., Schaffner, E., Foraster, M., Viennau, D., Cajochen, C., Wunderli, J. M., Roosli, M., Stolz, D., Pons, M., Imboden, M., Probst-Hensch, N., 2020. The independent association of source-specific transportation noise exposure, noise annoyance and noise sensitivity with health-related quality of life. Environ. Int. 143, 105960 https://doi.org/10.1016/j.envint.2020.105960.
Choi, K.H., Park, M.S., Lim, M.H., Hur, J.I., Noh, S.R., Jeong, W.C., Cheong, H.K., Ha, M., 2021. Who has sustained psychological symptoms nine years after the Hebei Spirit oil spill?: the health effect research on Hebei Spirit oil spill (HEROS) study. J. Environ. Manag. 294, 112936 https://doi.org/10.1016/j.jenvman.2021.112936.
Cuthbertson, C.A., Newkirk, C., Ilardo, J., Loveridge, S., Skidmore, M., 2016. Angry, scared, and unsure: mental health consequences of contaminated water in Flint, Michigan. J. Urban Health 93, 899–908. https://doi.org/10.1007/s11524-016-0089-y.
Dahlgren, M.K., Lambros, A.M., Smith, R.T., Sagar, K.A., El-Abboud, C., Gruber, S.A., 2022. Clinical and cognitive improvement following full-spectrum, high-cannabidiol treatment for anxiety: open-label data from a two-stage, phase 2 clinical trial. Commun. Med. 2, 1–10. https://doi.org/10.1038/s43856-022-00202-8.
Deng, Y., Zhao, H., Liu, Y., Liu, H., Shi, J., Zhao, C., He, M., 2022. Association of using biomass fuel for cooking with depression and anxiety symptoms in older Chinese adults. Sci. Total Environ. 811, 152256 https://doi.org/10.1016/j.scitotenv.2021.152256.
Downey, L., Van Willigen, M., 2005. Environmental stressors: the mental health impacts of living near industrial activity. J. Health Soc. Behav. 46, 289–305. https://doi.org/10.1177/002214650504600306.
Dzhambov, A.M., Hartig, T., Tilov, B., Atanasova, V., Makakova, D.R., Dimitrova, D.D., 2019. Residential greenspace is associated with mental health via intertwined capacity-building and capacity-restoring pathways. Environ. Res. 178, 108708 https://doi.org/10.1016/j.envres.2019.108708.
European Environment Agency, 2022. Beating cancer – the role of Europe's environment. Available at. https://www.eea.europa.eu/publications/environmental-burden-of-cancer/beating-cancer-the-role-of-europes.
Eze, I.C., Foraster, M., Schaffner, E., Vienneau, D., Pieren, R., Imboden, M., Wunderli, J.-M., Cajochen, C., Brink, M., Röösli, M., 2020. Incidence of depression in relation to transportation noise exposure and noise annoyance in the SAPALDIA study. Environ. Int. 144, 106014 https://doi.org/10.1016/j.envint.2020.106014.
Firdaus, G., 2017. Built environment and health outcomes: identification of contextual risk factors for mental well-being of older adults. Ageing Int. 42, 62–77. https://doi.org/10.1007/s12126-016-9276-0.
Gao, W., Tu, R.X., Li, H., Fang, Y.L., Que, Q.M., 2020. In the subtropical monsoon climate high-density city, what features of the neighborhood environment matter most for public health? Int. J. Environ. Res. Public Health 17. https://doi.org/10.3390/ijerph17249566.
Gignac, F., Righi, V., Toran, R., Paz Errandonea, L., Ortiz, R., Mijling, B., Naranjo, A., Nieuwenhuijsen, M., Creus, J., Basagaña, X., 2022. Short-term NO2 exposure and cognitive and mental health: a panel study based on a citizen science project in Barcelona, Spain. Environ. Int. 164, 107284 https://doi.org/10.1016/j.envint.2022.107284.
González-Blanch, C., Hernández-de-Hita, F., Muñoz-Navarro, R., Ruíz-Rodríguez, P., Medrano, L.A., Cano-Vindel, A., 2018. The association between different domains of quality of life and symptoms in primary care patients with emotional disorders. Sci. Rep. 8, 1–10. https://doi.org/10.1038/s41598-018-28995-6.
Goto, A., Bromet, E.J., Ota, M., Ohtsuru, A., Yasumura, S., Fujimori, K., 2017. The Fukushima nuclear accident affected mothers' depression but not maternal confidence. Asia Pac. J. Public Health 29, 139s–150s. https://doi.org/10.1177/1010539516684945.
Goto, A., Tsugawa, Y., Fujimori, K., 2019. Factors associated with intention of future pregnancy among women affected by the Fukushima nuclear accident: analysis of Fukushima health management survey data from 2012 to 2014. J. Epidemiol. 29, 308–314. https://doi.org/10.2188/jea.JE20180015.
Halcomb, E., Thompson, C., Morris, D., James, S., Dilworth, T., Haynes, K., Batterham, M., 2022. Impacts of the 2019/20 bushfires and COVID-19 pandemic on the physical and mental health of older Australians: a cross-sectional survey. Fam. Pract. https://doi.org/10.1093/fampra/cmac138.
Hao, G., Zuo, L., Xiong, P., Chen, L., Liang, X., Jing, C., 2022. Associations of PM2.5 and road traffic noise with mental health: Evidence from UK Biobank. Environ. Res. 207 https://doi.org/10.1016/j.envres.2021.112221.
Harvey, S.B., Joyce, S., Tan, L., Johnson, A., Nguyen, H., Modini, M., Groth, M., 2014. Developing a mentally healthy workplace: a review of the literature. In: National Mental Health Commission. doi:APO-57690.
Hautekiet, P., Saenen, N.D., Demarest, S., Keune, H., Pelgrims, I., Van der Heyden, J., De Clercq, E.M., Nawrot, T.S., 2022. Air pollution in association with mental and self-rated health and the mediating effect of physical activity. Environ. Health 21, 29. https://doi.org/10.1186/s12940-022-00839-x.
Hori, A., Hoshino, H., Miura, I., Hisamura, M., Wada, A., Itagaki, S., Kunii, Y., Matsumoto, J., Mashiko, H., Katz, C.L., Yabe, H., Niwa, S.I., 2016. Psychiatric outpatients after the 3.11 complex disaster in Fukushima, Japan. Ann. Glob. Health 82, 798–805. https://doi.org/10.1016/j.aogh.2016.09.010.
Humphreys, A., Walker, E.G., Bratman, G.N., Errett, N.A., 2022. What can we do when the smoke rolls in? An exploratory qualitative analysis of the impacts of rural wildfire smoke on mental health and wellbeing, and opportunities for adaptation. BMC Public Health 22, 41. https://doi.org/10.1186/s12889-021-12411-2.
Jung, M., Cho, D., Shin, K., 2019. The impact of particulate matter on outdoor activity and mental health: a matching approach. Int. J. Environ. Res. Public Health 16. https://doi.org/10.3390/ijerph16162983.
Klompmaker, J.O., Hoek, G., Bloemsma, L.D., Wijga, A.H., van den Brink, C., Brunekreef, B., Lebret, E., Gehring, U., Janssen, N.A.H., 2019. Associations of combined exposures to surrounding green, air pollution and traffic noise on mental health. Environ. Int. 129, 525–537. https://doi.org/10.1016/j.envint.2019.05.040.
Kruger, D.J., Cupal, S., Franzen, S.P., Kodjebacheva, G., Bailey, E.S., Key, K.D., Kaufman, M.M., 2017. Toxic trauma: household water quality experiences predict posttraumatic stress disorder symptoms during the Flint, Michigan, water crisis. J. Community Psychol. 45, 957–962. https://doi.org/10.1002/jcop.21898.
Lan, Y., Roberts, H., Kwan, M.P., Helbich, M., 2022. Daily space-time activities, multiple environmental exposures, and anxiety symptoms: a cross-sectional mobile phone-based sensing study. Sci. Total Environ. 834, 155276 https://doi.org/10.1016/j.scitotenv.2022.155276.
Lee, H., Jung, J., Myung, W., Baek, J.H., Kang, J.M., Kim, D.K., Kim, H., 2019. Association between dust storm occurrence and risk of suicide: case-crossover analysis of the Korean national death database. Environ. Int. 133, 105146 https://doi.org/10.1016/j.envint.2019.105146.
Ma, J., Li, C., Kwan, M.P., Chai, Y., 2018. A multilevel analysis of perceived noise pollution, geographic contexts and mental health in Beijing. Int. J. Environ. Res. Public Health 15. https://doi.org/10.3390/ijerph15071479.
Ma, Y., Wang, W., Li, Z., Si, Y., Wang, J., Chen, L., Wei, C., Lin, H., Deng, F., Guo, X., Ni, X., Wu, S., 2022. Short-term exposure to ambient air pollution and risk of daily hospital admissions for anxiety in China: a multicity study. J. Hazard. Mater. 424, 127535 https://doi.org/10.1016/j.jhazmat.2021.127535.
Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A.M., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M.J., Lupp, G., Richardson, E.A., Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., Fuertes, E., 2017. Exploring pathways linking greenspace to health: theoretical and methodological guidance. Environ. Res. 158, 301–317. https://doi.org/10.1016/j.envres.2017.06.028.
Maybery, D., Jones, R., Dipnall, J.F., Berger, E., Campbell, T., McFarlane, A., Carroll, M., 2020. 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 33, 216–230. https://doi.org/10.1080/10615806.2019.1695523.
McDougall, C.W., Hanley, N., Quilliam, R.S., Oliver, D.M., 2022. Blue space exposure, health and well-being: does freshwater type matter? Landsc. Urban Plan. 224, 104446 https://doi.org/10.1016/j.landurbplan.2022.104446.
Moher, D., Stewart, L., Shekelle, P., 2015. All in the family: systematic reviews, rapid reviews, scoping reviews, realist reviews, and more. Syst. Rev. 4 (1), 1–2. https://doi.org/10.1186/s13643-015-0163-7.
Muhammad, M., De Loney, E.H., Brooks, C.L., Assari, S., Robinson, D., Caldwell, C.H., 2018. "I think that's all a lie…i think it's genocide": applying a critical race praxis to youth perceptions of flint water contamination. Ethn. Dis. 28, 241–246. https://doi.org/10.18865/ed.28.S1.241.
Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E., 2018a. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med. Res. Methodol. 18, 143. https://doi.org/10.1186/s12874-018-0611-x.
Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E., 2018b. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med. Res. Methodol. https://doi.org/10.1186/s12874-018-0611-x.
Nakao, M., Yamauchi, K., Ishihara, Y., Solongo, B., Ichinnorov, D., Breugelmans, R., 2016. Validation of the Mongolian version of the SF-36v2 questionnaire for health status assessment of Mongolian adults. Springerplus 5, 607. https://doi.org/10.1186/s40064-016-2204-7.
Nguyen, A.M., Malig, B.J., Basu, R., 2021. The association between ozone and fine particles and mental health-related emergency department visits in California, 2005-2013. PLoS One 16. https://doi.org/10.1371/journal.pone.0249675.
OECD, 2023. Fitter minds, fitter jobs: from awareness to change in integrated mental health, skills and work policies. Available at. https://www.oecd-ilibrary.org/sites/c9ee4f29-en/index.html?itemId=/content/component/c9ee4f29-en (Accessed 21 Feb 2023).
Pagliaccio, D., Herbstman, J.B., Perera, F., Tang, D., Goldsmith, J., Peterson, B.S., Rauh, V., Margolis, A.E., 2020. Prenatal exposure to polycyclic aromatic hydrocarbons modifies the effects of early life stress on attention and thought problems in late childhood. J. Child Psychol. Psychiatry 61, 1253–1265. https://doi.org/10.1111/jcpp.13189.
Peters, M.D.J., Godfrey, C., McInerney, P., Munn, Z., Tricco, A., Khalil, H., 2020. Chapter 11: Scoping Reviews (2020 version) in E. Aromataris E and Z. Munn, Joanna Briggs Institute (JBI) Manual for Evidence Synthesis, JBI. Available at doi:10.46658/JBIMES-20-12 (accessed 8 December 2021).

Pun, V.C., Manjourides, J., Suh, H., 2017. Association of ambient air pollution with depressive and anxiety symptoms in older adults: results from the NSHAP study. Environ. Health Perspect. 125, 342–348. https://doi.org/10.1289/ehp494.

Qiu, H., Wang, L., Luo, L., Shen, M., 2022. Gaseous air pollutants and hospitalizations for mental disorders in 17 Chinese cities: association, morbidity burden and economic costs. Environ. Res. 204, 111928 https://doi.org/10.1016/j.envres.2021.111928.

Rajper, S.A., Ullah, S., Li, Z., 2018. Exposure to air pollution and self-reported effects on Chinese students: a case study of 13 megacities. PLoS One 13, e0194364. https://doi.org/10.1371/journal.pone.0194364.

Remennick, L.I., 2002. Immigrants from Chernobyl-affected areas in Israel: the link between health and social adjustment. Soc. Sci. Med. 54, 309–317. https://doi.org/10.1016/s0277-9536(01)00030-2.

Rickenbacker, H.J., Vaden, J.M., Bilec, M.M., 2020. Engaging citizens in air pollution research: investigating the built environment and indoor air quality and its impact on quality of life. J. Archit. Eng. 26 https://doi.org/10.1061/(asce)ae.1943-5568.0000439.

Rodney, R.M., Swaminathan, A., Calear, A.L., Christensen, B.K., Lal, A., Lane, J., Leviston, Z., Reynolds, J., Trevenar, S., Vardoulakis, S., Walker, I., 2021. Physical and mental health effects of bushfire and smoke in the Australian Capital Territory 2019–20. Front. Public Health 9. https://doi.org/10.3389/fpubh.2021.682402.

Salehzadeh, H., Ebrahemzadih, M., Nourani, M.R., Kourghi, M., Taheri, R.A., 2019. The impact of Lead contamination on psychiatric disorders and quality of life. J. Biochem. Technol. 10, 18–27.

Sansom, G., Parras, J., Parras, A., Nieto, Y., Arellano, Y., Berke, P., McDonald, T., Shipp, E., Horney, J.A., 2017. The impacts of exposure to environmental risk on physical and mental health in a small geographic community in Houston, TX. J. Community Health 42, 813–818. https://doi.org/10.1007/s10900-017-0322-y.

Santiago-Rivera, A.L., Skawenio Morse, G., Haase, R.F., McCaffrey, R.J., Tarbell, A., 2007. Exposure to an environmental toxin, quality of life and psychological distress. J. Environ. Psychol. 27, 33–43. https://doi.org/10.1016/j.jenvp.2006.12.004.

Simpson, D.M., Weissbecker, I., Sephton, S.E., 2011. Extreme weather-related events: implications for mental health and well-being. Clim. Chang. Human Well-being 57–78.

Smout, M.F., 2019. The factor structure and predictive validity of the Kessler psychological distress scale (K10) in children and adolescents. Aust. Psychol. 54, 102–113. https://doi.org/10.1111/ap.12376.

Supreme Court of Victoria, 2020. Director of Public Prosecutions V. Hazelwood Power Corporation Pty Ltd.

Thilakaratne, R.A., Malig, B.J., Basu, R., 2020. Examining the relationship between ambient carbon monoxide, nitrogen dioxide, and mental health-related emergency department visits in California, USA. Sci. Total Environ. 746, 140915 https://doi.org/10.1016/j.scitotenv.2020.140915.

Thomson, E.M., Christidis, T., Pinault, L., Tjepkema, M., Colman, I., Crouse, D.L., van Donkelaar, A., Martin, R.V., Hystad, P., Robichaud, A., Menard, R., Brook, J.R., Burnett, R.T., 2020. Self-rated stress, distress, mental health, and health as modifiers of the association between long-term exposure to ambient pollutants and mortality. Environ. Res. 191, 109973 https://doi.org/10.1016/j.envres.2020.109973.

Tian, T., Chen, Y., Zhu, J., Liu, P., 2015. Effect of air pollution and rural-urban difference on mental health of the elderly in China. Iran. J. Public Health 44, 1084–1094.

Tjalvin, G., Magerøy, N., Bråtveit, M., Lygre, S.H., Hollund, B.E., Moen, B.E., 2017. Odour as a determinant of persistent symptoms after a chemical explosion, a longitudinal study. Ind. Health 55, 127–137. https://doi.org/10.2486/indhealth.2016-0155.

Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Moher, D., Peters, M.D., Horsley, T., Weeks, L., Hempel, S., 2018. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Annals of internal medicine 169 (7), 467–473. https://doi.org/10.7326/M18-0850.

US EPA, 2022. Linking air pollution and heart disease. Available at. https://www.epa.gov/sciencematters/linking-air-pollution-and-heart-disease (Accessed 28 November 2022).

Victorian Government, 2023. Environment Protection Act 2017, 51/2017.

Wang, R., Liu, Y., Xue, D., Yao, Y., Liu, P., Helbich, M., 2019. Cross-sectional associations between long-term exposure to particulate matter and depression in China: the mediating effects of sunlight, physical activity, and neighborly reciprocity. J. Affect. Disord. 249, 8–14. https://doi.org/10.1016/j.jad.2019.02.007.

Wang, R., Yang, B., Liu, P., Zhang, J., Liu, Y., Yao, Y., Lu, Y., 2020. The longitudinal relationship between exposure to air pollution and depression in older adults. Int. J. Geriatr. Psychiatry 35, 610–616. https://doi.org/10.1002/gps.5277.

Xue, T., Guan, T.J., Zheng, Y.X., Geng, G.N., Zhang, Q., Yao, Y., Zhu, T., 2021. Long-term PM2.5 exposure and depressive symptoms in China: a quasi-experimental study. In: Lancet Regional Health-Western Pacific 6. https://doi.org/10.1016/j.lanwpc.2020.100079.

Yackerson, N.S., Zilberman, A., Todder, D., Kaplan, Z., 2014. The influence of air-suspended particulate concentration on the incidence of suicide attempts and exacerbation of schizophrenia. Int. J. Biometeorol. 58, 61–67. https://doi.org/10.1007/s00484-012-0624-9.

Yamazaki, S., Nitta, H., Fukuhara, S., 2006. Associations between exposure to ambient photochemical oxidants and the vitality or mental health domain of the health related quality of life. J. Epidemiol. Community Health 60, 173–179. https://doi.org/10.1136/jech.2005.039560.

Yang, Z.M., Song, Q.H., Li, J., Zhang, Y.Q., Yuan, X.C., Wang, W.Q., Yu, Q., 2021. Air pollution and mental health: the moderator effect of health behaviors. Environ. Res. Lett. 16 https://doi.org/10.1088/1748-9326/abe88f.

Yolton, K., Khoury, J.C., Burkle, J., LeMasters, G., Cecil, K., Ryan, P., 2019. Lifetime exposure to traffic-related air pollution and symptoms of depression and anxiety at age 12 years. Environ. Res. 173, 199–206. https://doi.org/10.1016/j.envres.2019.03.005.

Yuan, X., Li, H., Zhao, J., 2020. Impact of environmental pollution on health—evidence from cities in China. Soc. Work Public Health 35, 413–430. https://doi.org/10.1080/19371918.2020.1805084.

Zhang, X., Zhang, X.B., Chen, X., 2017. Happiness in the air: how does a dirty sky affect mental health and subjective well-being? J. Environ. Econ. Manag. 85, 81–94. https://doi.org/10.1016/j.jeem.2017.04.001.

Zijlema, W.L., Wolf, K., Emeny, R., Ladwig, K.H., Peters, A., Kongsgard, H., Hveem, K., Kvaloy, K., Yli-Tuomi, T., Partonen, T., Lanki, T., Eeftens, M., de Hoogh, K., Brunekreef, B., Stolk, R.P., Rosmalen, J.G., 2016. The association of air pollution and depressed mood in 70,928 individuals from four European cohorts. Int. J. Hyg. Environ. Health 219, 212–219. https://doi.org/10.1016/j.ijheh.2015.11.006.

Zu, D., Zhai, K., Qiu, Y., Pei, P., Zhu, X., Han, D., 2020. The impacts of air pollution on mental health: evidence from the chinese university students. Int. J. Environ. Res. Public Health 17, 1–15. https://doi.org/10.3390/ijerph17186734.