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ARTICLE REVIEW

The Impact of Urban Residential Noise and Air Pollution on Youth Mental Health: A Scoping Review

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ABSTRACT

Introduction Urban noise and air pollution contribute indirectly to mental health disorders, particularly among adolescents and young adults, due to their ongoing neurodevelopment and increased exposure to environmental pollutants. Hence, it is crucial to understand the impact of urban environmental pollution on youth's mental health.

Methods This scoping review was conducted to evaluate the impact of urban air and noise pollution on youth mental health. Articles published between January 2014 and October 2024 were identified through four databases (PubMed, Scopus, Web of Science, and ProQuest), using terms such as noise pollution, air pollution, mental health, and youth. Studies involving urban youth and mental health as an outcome were included. Data from eligible studies were synthesized to identify patterns and gaps in the literature.

Results Fourteen studies (n = 14) were included out of 1555 records retrieved. Long term exposure to air pollutants, such as PM 2.5, PM 10, and NO2, were consistently associated with negative mental health outcomes, including poor mental health (PM2.5: OR 1.19, 95% CI 1.03-1.38; NO2: OR 1.23, 95% CI 1.04-1.38; PM10: OR 1.07, 95% CI 0.98-1.17); depression and anxiety (PM2.5: OR 1.24, 95% CI 1.12-1.38; PM10: OR = 1.87, 95 % CI 1.69–2.07); and internalising symptoms. Short-term exposure also contributed to indirect mental health burden through increased emergency visits and increased psychotropic medications. Findings were heterogeneous for noise pollution, with short-term exposure linked to generally poor mental health, whereas long-term exposure was associated with depression, anxiety, and suicidal risk in some studies.

Conclusions The review highlights the significant effect of urban air and noise pollution on youth mental health. Targeted and effective interventions, including urban planning, environmental regulations, and youth-focused public health strategies, are necessary to mitigate these negative effects.

Keywords Urban pollution; youth mental health; air pollution; noise pollution; public health; environmental stressors.

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INTRODUCTION

Residential noise and air pollution have become major public health concerns. Such environmental factors have been identified as potential contributors to the rising prevalence of mental health disorders among adults, as well as children and youth, especially in urbanised regions with dense population.[1-5] Urban environmental exposures are not evenly distributed across populations. Urban youth from low-socioeconomic or marginalised communities are more vulnerable as they are more likely to live in the areas with high traffic density, industrial activities, crowded living circumstances and limited green space.[6,7]

Mental health, defined as 'a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community',[8] has been recognised as the leading cause of disease burden.[9] Risk of mental health is highly prevalent in adolescents and youth with 48.4% of mental disorders occur before the age of 18 and 62.5% occur before the age of 25.[10] Globally, 22% of first onset for anxiety or depression symptoms occurred in people within 20-29 age group.[11]

There is growing evidence that exposure to air pollutants such as PM10, PM2.5, nitrogen oxide (NO), nitrogen dioxide (NO2), Ozone (O3), elemental carbon (EC) and polycyclic aromatic hydrocarbons (PAHs), are associated with psychological distress including depression, anxiety and psychotic disorders.[3,12] These associations are partly explained by the pollutant-related neuroinflammatory responses that may disrupt brain development.[13] The pollutant-related neuroinflammation effect is a particular concern in pollutant-exposed youth because of their ongoing maturational process of neurodevelopment and immature cerebral vasculature that extends from adolescence to young adulthood which make them more vulnerable.[14,15]

Similarly, noise pollution, especially from traffic and community sources, has been associated with psychological distress, sleep disruption, cognitive impairment and chronic stress.[16,17] World Health Organisation (WHO) reported that one in three European Union citizens was affected by noise annoyance and one in four reported sleep disturbance as a consequences of it.[18] Environmental noise pollution is defined as high level of unwanted sound including noise annoyance and community noise.[19] The detrimental health effects of noise exposure involve a complex interaction of behavioural and psychological factors. Youth exposed to chronic noise pollution have higher risk of emotional dysregulation and attention-related issues (hyperactivity, attention deficit).[20-22]

The combination of air and noise pollution exposure in youth creates a high-risk setting that may hasten mental health disorders which could persist into adulthood. However, there are limited studies that focus on environmental stressors and mental health in youth, particularly urban youth. Youth can be defined as the transition period from dependency in childhood to adulthood's independence. United Nations (UN) defines youth as person aged 15 to 24 years old. [23] Malaysia, on the other hand, defines youth as person in between age of 15 to 30 years old.[24] Understanding the cumulative effect of urban air and noise pollution on youth mental health is crucial given the rapid urbanisation of Malaysia and the subsequent increase in urban population.[25] This study aims to review the current relevant literature on the air and noise pollution exposure as the risks of mental health disorders among youth focusing on articles published between January 2014 until October 2024. The review findings summarised the association of noise pollution on mental health, air pollution on mental health and the cumulative effect of both air and noise pollution on mental health, focusing on youth population in urban settings.

METHODS

The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines.

Search Strategy

Literature search was made from four databases, namely PubMed, Web of Science, Scopus and ProQuest. The databases were selected based on the coverage of the topic of interest. On the basis of this scoping review, the search strategy included the combinations of following terms to identify relevant literature on this topic: "noise pollution", "noise", "air pollution", "air quality", "emissions", "mental health", "mental disorder", "anxiety", "depression", "stress", "youth", "young adults", "urban", "city". The full list of search terms is provided in Appendix A. The searches include papers from the last 10 years (1 January 2014 to 26 October 2024), papers published in English language and includes all types of study (randomised control trial, cohort, case-control, cross-sectional and case report studies). The title and abstract were analysed to removes any duplicates. Full papers were retrieved and screened for eligibility. The reference lists of the included studies were also checked for any relevant articles.

Review Process

Two reviewers independently screened the retrieved full papers for eligibility and any disagreements were resolved through consultation with a third reviewer. Studies were included if the paper (1) involved respondents aged 15 to 30 years old, (2) were conducted in urban settings, (3) exposure to air and/or noise pollutants, and (4) reported mental health outcomes. Data from the included articles was

extracted using a standardised data extraction form into Microsoft Excel. The information collected in the form includes: author/publication year; country; study population; exposure; study design; outcome; and conclusion. Each significant result will be included and a scoping review will be used to synthesize these findings.

RESULTS

Study Characteristics

1555 records were identified from the search strategy and after reviewing, 14 records were included in this review (Figure 1). Seven of these were cross-sectional studies,[26-32] three were cohort studies,[33-35] and four used a longitudinal design.[36-39] Majority of the studies were conducted in Europe and United Kingdom (UK) nine out of 14), three studies were conducted in Asia, while one study each was conducted in United States and Canada. All the studies used youth as participants, either partially or exclusively.

Six articles studied the association of air pollution and mental health, whereas five articles studied the association of noise pollution on mental health. Only three studies measure both air and noise pollution and its association with mental health. Eight out of 14 included articles studied long term exposure effect of study pollutants on outcomes, while five studies look at short term pollutant exposure to outcomes. The summary of the included study characteristics is tabulated in Table 1 below.

Environment Pollution and Mental Health

Based on the review, majority of the articles showed mental health related symptoms among youth exposed to different sources of air and/or noise exposure. These outcomes are divided by (a) general mental health; (b) depression and anxiety; (c) stress; (d) suicide; and (e) indirect mental health burden. The findings are summarised in Table 2.

General mental health

Five studies discussed on the general mental health following exposure to surrounding air pollution. Three studies measure the effect of long-term exposure to air pollution reported significant findings on mental health. A study by Reuben et al. (2021) reported youth exposed to higher nitrogen oxides (NOx) were associated with 1.40-point increase (95% CI 0.41-2.38; p=0.05) in general psychopathology at age 18.[36] One longitudinal studies examining the one-year effect of ambient air pollution of PM2.5 showed that higher exposure to PM2.5 leads to increase in internalising symptoms, such as anxiety or depression (standardised β = 0.036; 95% CI 0.01-0.06; p=0.002).[37] Whereas, another longitudinal study found that higher exposure to ambient air pollutants were associated with poorer mental health, specifically with PM2.5 (OR 1.19, 95% CI 1.03-1.38; per 1.15 μg/m3 increase in PM2.5), PM10 (OR 1.07, 95% CI 0.98-1.17; per 1.15 μg/m3 increase in PM10) and NO2 (OR 1.23, 95% CI 1.09-1.38; per 9.11 μg/m3 increase in NO2).[34]

The association of noise pollution and general mental health showed different findings in the included studies. Two related studies conducted by the same author investigated the impact of short-term road traffic noise exposure on two different set of populations within the same city. The first study, involving local students aged 15 to 25 years old, found that higher residential noise exposure was indirectly associated with poorer mental health through noise annoyance (β=0.21; 95% CI 0.10-0.38; p<0.001).[26] Whereas, the second study involving university students aged 18 to 25 years old, reported a direct association between higher short-term noise exposure and poorer mental health (Crude OR 1.95; 95% CI 0.76-3.15; p = 0.001).[32] In contrast, long-term exposure to road traffic and railway noise showed no significant association to mental health outcomes.[34]

Depression and anxiety

Four studies examined the effects of environment pollution on depression and anxiety. One recent study from China found that long-term exposure to particulate matter of PM1, PM2.5 and PM10 was significantly associated with increased risk of depression among adolescents and youth (PM1: OR = 1.21, 95 % CI 1.12–1.32; PM2.5: OR = 1.24, 95 % CI 1.19–1.38; PM10: OR = 1.87, 95 % CI 1.69–2.07).[29] However, a UK-based study found no association between long-term exposure of PM2.5 and anxiety during childhood.[39]

In terms of noise pollution, both short-term or long-term exposures to urban noises were linked to mood disturbances. Long-term exposure to road traffic noise was associated with increased odds for anxiety during both childhood (AOR=1.19, 95% CI 1.03-1.38; p=0.02) and adolescence (AOR=1.22, 95% CI 1.02-1.45; p=0.03).[39] Short-term exposure to neighbourhood and environmental noise was also associated with increased risks of depression and anxiety.[28,31] Additionally, a recent study by Yun et al. (2024) found that residents living in high-noise areas had a 1.55 times greater risk of depression than those in the lowest noise areas (95% CI 1.04-2.31).

Table 1 The study characteristics of included studies

Author (year) Country	Study design	Sample population	Sample size	Exposure pollutant	Exposure duration	Pollution source/location	Parameters
Air Pollution:							
Okuyama et al[27] Japan	Cross-sectional	Children (aged 0 to 19 years) and adults (aged 20 to 69 years) in Japan	3995	PM2.5	Undefined	Within jurisdiction	Air Quality Index (AQI)
Reuben et al[36] UK	Longitudinal	Participants from the UK Environmental-Risk (E-Risk) Longitudinal Twin Study	2039	PM2.5 and NOx	Long term From childhood to 18 years of age	Residential address	Mean annual exposure, μg/m^3
Szyszkowicz et al[33] Canada	Cohort (Retrospective)	Patients aged 8 to 24 years old who visited Toronto emergency departments in 2016	83,985	PM2.5, NO2 and daily maximum 8h O3	Short term Same day and one-day lagged effects	City	Daily concentration level, μg/m^3
Smolker et al[37] United States	Longitudinal	Children aged 10 to 18 years old from the ABCD Study National Data Archive	10,783	PM2.5	Long term	Residential address	Annual average of daily ambient PM2.5 levels across 2016
Oudin et al[38] Sweden	Longitudinal	Population under 18 years of age in 4 major counties	552,221	NO2, PM10 and PM2.5	Long term	City	Annual exposure estimates, μg/m^3
Yuan et al[29] China	Cross sectional	Students aged 10 to 25 years old	312,390	PM1, PM2.5 and PM10	Long term	City	Yearly average concentrations for each survey year (2019 to 2022)
Noise Pollution:							
Dzhamboy et al[26] Germany	Cross-sectional	Students aged 15 to 25 years old residing in Plovdiv for at least one year	688	Residential road traffic noise	Short term	Residential address	Day equivalent noise level, LAeq
Yun et al[28] Korea	Cross sectional	Children and adults registered in 2019 Korean Community Health Survey (CHS)	30630	Environmental noise in 15 cities across Korea	Short term	City	Equivalent Continous Sound Pressure Level, Leq

Author (year) Country	Study design	Sample population	Sample size	Exposure pollutant	Exposure duration	Pollution source/location	Parameters
Berkers et al[30] Netherlands	Cross sectional	Adults aged 19 to 64 years	25,236	Noise annoyance	Long term	Road traffic, railways, aircraft, transportation, neighbourhood, construction sites, industry and commercial area	Noise annoyance scale, 0 "no noise annoyance" to 10 "high noise annoyance"
Jensen et al[31] Denmark	Cross sectional	Adults (16 years and older) living in multi-storey housing	25,000	Noise annoyance	Short term	Neighbourhood noise	Noise annoyance level
Wicki et al[35] Switzerland	Cohort study (prospective)	Adults aged 15 years and older	Over 5 million	Noise exposure	Long term	Road traffic noise, railway noise and aircraft noise	Daily noise exposure estimates, Lden
Air and Noise Pollution:							
Dzhambov et al[32] Germany	Cross-sectional	University students aged 18 to 35 years old in city of Plovdiv	720	1. Residential noise exposure 2. NO2	Short term	Residential noise	1. Day equivalent noise level, LAeq 2. NO2 exposure estimate, µg/m^3
Newbury et al[39] UK	Longitudinal	Participants from the UK birth cohort (ALSPAC) (aged 13 to 24 years)	9065	1. NO2 and PM2.5 2. Road traffic noise pollution	Long term	Road traffic	1. Annual NO2 and PM2.5 exposure estimate 2. Annual day and night noise pollution level (low to medium, high and very high)
Bloemsma et al[34] Netherlands	Cohort study	Children and adult from Dutch PIAMA cohort between aged 11 to 20 years	3059	1. PM10 and PM2.5 and NO2 2. Road traffic and railway noise	Long term	Road traffic and railway	Annual average estimates concentration, µg/m^3 and Annual estimates for road traffic and railway noise, Lden

Note(s): UK = United Kingdom, PM = Particulate matter, NOX = Nitrogen oxides, NO2 = Nitrogen dioxides, O3 = Ozone, ABCD = Adolescent Brain Cognitive Development, PIAMA = Prevention and Incidence of Asthma and Mite Allergy.

Table 2 Summary of outcome findings based on mental health outcome

Mental health outcomes	Author (year) Country	Pollution	Exposure	Exposure duration	Outcome assessment	Outcome measurement	Findings summary	Effect on mental health
General mental health	Reuben et al[35] UK	Air pollution	PM2.5 and NOx	Long term	General psychopathology	Structured interview at age 18	Higher NOx exposure linked to greater psychopathology at age 18. Each interquartile range increment in NOx exposure was associated with a 1.40-point increase (95% CI 0.41-2.38; p=0.05) in general psychopathology.	↑ Adverse effect (NOx); ↔ No effect (PMM2.5)
	Smolker et al[36] United States	Air pollution	PM2.5	Long term	Internalising (anxiety, depression) and externalising symptoms (conduct disorder, related disorder)	Child Behaviour Checklist (CBCL) at baseline and at follow-up (1 year, 2 years and 3 years)	Every additional day of PM2.5 exposure above standard (>35 ug/m^3 24-h average) was associated with 0.098 increase in internalizing symptoms (standardised B = 0.052; 95% CI 0.03-0.08, p=0.006). Externalizing symptoms was not associated with annual average exposure to PM2.5.	↑ Adverse effect
	Dzhambov et al[25] Germany	Noise pollution	Residential road traffic noise (L_{den}; day-evening-night level)	Short term	General mental health	General Health Questionnaire (GHQ-12)	Higher noise exposure was associated with poor mental health only indirectly. The indirect pathway through noise annoyance and poor mental was statistically significant ($\beta_{unstandardised}$=0.27; 95% CI 0.13-0.48; p<0.05, for every 5-dB increase in L_{den})	↑ Adverse effect
	Dzhambov et al[31] Germany	Air and noise pollution	1. Residential noise exposure 2. NO2	Short term	General mental health	General Health Questionnaire (GHQ-11)	Higher residential noise (mean L_{Aeq} of 67.05 dB) linked to poorer mental health (Crude OR 1.95; 95% CI 0.76-3.15; p = 0.001). Air pollution (NO2) indirectly	↑ Adverse effect (noise); ↔ No effect (NO2)

Mental health outcomes	Author (year) Country	Pollution	Exposure	Exposure duration	Outcome assessment	Outcome measurement	Findings summary	Effect on mental health
							associated with mental health via annoyance.	
	Bloemsma et al[33] Netherlands	Air and noise pollution	1. PM10 and PM2.5, NO2 2. Road traffic and railway noise	Long term	Mental well being	Mental Health Inventory (MHI-5) completed at age 11, 14, 17 and/or 20 years	Higher air pollution exposure was associated with higher odds of poor mental wellbeing. OR 1.23, 95% CI 1.09-1.38 per 9.11 μg/m³ increase in NO2; OR 1.07, 95% CI 0.98-1.17 per 1.15 μg/m³ increase in PM10; OR 1.19, 95% CI 1.03-1.38 per 1.15 μg/m³ increase in PM2.5. Traffic noise was not related to mental wellbeing throughout adolescence.	↑ Adverse effect (PM10, PM2.5, NO2); ↔ No effect (noise)
Depression and anxiety	Yuan et al[28] China	Air pollution	PM1, PM 2.5 and PM10	Long term	Depressive symptoms	Surveillance data from year 2019 to 2022 of common diseases	Significant associations were found between PM1 (OR = 1.21, 95 % CI 1.12–1.32), PM2.5 (OR = 1.24, 95 % CI 1.19–1.38), and PM10 (OR = 1.87, 95 % CI 1.69–2.07) and increased risks of depressive symptoms.	↑ Adverse effect
	Yun et al[27] Korea	Noise pollution	Environmental noise in 15 cities across Korea	Short term	Depressive symptoms	Patients Health Questionnaire (PHQ-9)	Environmental noise increases odds of depressive symptoms. Severe environmental noise in residential areas increases the risk of mild to moderate depressive symptoms by 1.46 times (95% CI 1.02-2.07) and 1.70 (95% CI 1.00-2.91) respectively	↑ Adverse effect
	Jensen et al[30] Denmark	Noise pollution	Noise annoyance	Short term	Depression and anxiety symptoms	Survey questionnaire on eight different health symptoms including	Neighbour noise annoyance within past two weeks was strongly associated with depressive and anxiety symptoms. Individuals being	↑ Adverse effect

Mental health outcomes	Author (year) Country	Pollution	Exposure	Exposure duration	Outcome assessment	Outcome measurement	Findings summary	Effect on mental health
						depression and anxiety symptoms	very bothered with neighbourhood noise during past two weeks had 2.10 (95% CI 1.39-3.18; p=0.0004) times higher odds of depression and 2.60 (95% CI 1.73-3.91; p<0.0001) times higher odds of anxiety compared to individuals who had not been annoyed.	
	Newbury et al[38] UK	Air and noise pollution	1. NO2 and PM2.5 2. Road traffic noise pollution	Long term	Anxiety	Semi-structured interview measured at age 13, 18 and 24 years.	Higher noise pollution exposure in childhood (AOR=1.19, 95% CI 1.03-1.38; *p*=0.02) and adolescence (AOR=1.22, 95% CI 1.02-1.45; *p*=0.03) was associated with elevated odds for anxiety. There were no association between PM2.5 exposure during childhood and anxiety.	↑ Adverse effect (noise) ↔ No effect (PM2.5)
Stress	Berkers et al[29] Netherlands	Noise pollution	Noise annoyance	Long term	Psychological distress level	Kessler-10 scale	Significant association between higher noise annoyance and psychological distress ($\beta_{standardised}$ = 0.16, p<0.001). Older adults (aged 51 to 64 years) experience less distress from noise as compared to younger adults (aged 19-35 years) ($\beta_{standardised}$ = -0.03, p = 0.02).	↑ Adverse effect
Suicide	Okuyama et al.[26] Japan	Air pollution	PM2.5	Long term	Suicide rates	National data on number of suicides by demographic characteristics from year 2014 until 2021	Combination of high air pollution and high unemployment rate increased suicide rates among children (42.66% in the short term, 35.96% in the long term) compared to adult (22.9% in short term). However, higher air	↑ Adverse effect

Mental health outcomes	Author (year) Country	Pollution	Exposure	Exposure duration	Outcome assessment	Outcome measurement	Findings summary	Effect on mental health
							pollution alone had no significant relationship with child suicide rate.	
	Wicki et al[34] Switzerland	Noise pollution	Noise exposure	Long term	Deaths from intentional self-harm	Mortality data from Swiss National Cohort from 1991 up to 2019	Road traffic noise was associated with an increased risk of death by suicide in all of the models, with an HR of 1.040 (95%CI 1.02-1.07) per 10-dB increase in noise exposure. Railway noise exposure was also associated with an increased risk of death by intentional self-harm, but it was of a smaller magnitude (HR=1:022; 95% CI 1.00-1.04). For aircraft noise, no linear association was observed (HR=0:997; 95%CI 0.97-1.03).	↑ Adverse effect
Indirect mental health burden	Szyszkowicz et al[32] Canada	Air pollution	PM2.5, NO2 and daily maximum 8h O3	Short term	ED visits for mental health disorders	Hospital data identified by ICD-10	Exposure to NO2 and PM2.5 were significantly associated with increased ED visits among youth in Toronto. Same-day and 1-day lag exposure to increase in PM2.5 concentration levels by one interquartile range increased the risk of ED visit by RR of 1.01 (95% CI 1.00-1.02) and 1.02 (95% CI 1.01-1.03), respectively. 1-day lag exposure to increase in NO2 concentration levels by one interquartile range increased the risk of ED visit (RR of 1.01, 95% CI 1.00-1.03).	↑ Adverse effect
	Oudin et al[37] Sweden	Air pollution	NO2, PM10 and PM2.5	Long term	Dispensed medicine related to psychiatric	Obtained from the Swedish National	10 µg/m3 increase of NO2, but not of PM10 or PM 2.5 significantly contributed to a	↑ Adverse effect (NO2);

Mental health outcomes	Author (year) Country	Pollution	Exposure	Exposure duration	Outcome assessment	Outcome measurement	Findings summary	Effect on mental health
					diagnoses from January 2005	Board of Health and Welfare	higher frequently prescription of psychotropic drugs in children and adolescents (HR=1.09, 95% CI 1.06-1.12).	↔ No effect (PM10, PM2.5)

Note(s): UK = United Kingdom, PM = Particulate matter, NOX = Nitrogen oxides, NO2 = Nitrogen dioxides, O3 = Ozone, OR = Odds ratio, HR = Hazard ratio

Furthermore, the risk of having mild to moderate depression were 1.46 times (95% CI 1.02-2.07) and 1.70 times (95% CI 1.00-2.91) higher in severe residential noise areas.[28] Neighbourhood noise annoyance was also reported to be associated with 2.10 times (95% CI 1.39-3.18; p=0.0004) higher odds of depression and 2.60 times (95% CI 1.73-3.91; p<0.0001) higher odds of anxiety in individuals bothered with two weeks of neighbourhood noise.[31]

Stress

A study conducted by Berkers et al. (2021) measure the impact of long-term noise annoyance on psychological distress level using the Kessler-10 scale.[30] The study reported significant association between higher noise annoyance to increased psychological distress (βstandardised = 0.16, p<0.001). The researcher also highlights that younger adult aged 19 to 35 years old experienced more distress from noise than older adults aged 51 to 64 years old (βstandardised = -0.03, p=0.02).[30]

Suicide

The association between air and noise pollution on suicide were conducted retrospectively in two national-level studies. A study in Japan reported higher suicide rates among children living in areas with both elevated PM2.5 levels and high unemployment combined (42.66% in the short term, 35.96% in the long term). However, PM2.5 alone was not significantly associated with child suicide rate.[27] In Switzerland, long-term exposure to road traffic and railway noise was linked to an increased risk of death by suicide (Hazard Ratio = 1.04; 95% CI 1.02-1.07), while no such association was found for aircraft noise exposure.[35]

Indirect mental health burden

Two studies showed significant association between air pollution and mental health by analysing emergency visits for mental disorder and psychotropic medications use. A 2016 study from Sweden found that long-term exposure to NO2 was significantly associated with increased prescription of psychotropic drugs among children and adolescents (HR=1.09, 95% CI 1.06-1.12).[38] In Canada, both same-day exposure (PM2.5: RR 1.01, 95% CI 1.00-1.02) and 1-day lag exposure (PM2.5: RR 1.02, 95% CI 1.01-1.03; NO2: RR of 1.01, 95% CI 1.00-1.03) to PM2.5 and NO2 were significantly associated with increased emergency visits for mental health issues among youth.[33]

DISCUSSION

The review highlights the multifaceted impact of air and noise pollution in urban areas on the mental health of youth, across various dimensions of psychological well-being such as anxiety, depression and suicide. The analysis integrates evidence from various research with differences in study design, geographical area – spanning across Japan, the United Kingdom, Canada, the United States and Sweden; and measurement approaches. This heterogeneity in findings provides a comprehensive understanding of the implications of environmental stressors pertaining to urban settings.

Air pollution and mental health

The review found consistent association between prolonged exposure to ambient air pollutants with negative mental health outcomes across different regions. For instance, studies from China, Netherlands and UK reported increased risk of poor mental wellbeing and depressive symptoms among youth exposed to PM2.5, PM10 and NO2 for long-term with odds ratio ranging between 1.07 to 1.87.[29, 34, 36, 37]

However, these associations across studies need to be interpreted with caution as these studies differed significantly in terms of methodology which could affected its comparability. Firstly, the exposure assessment methods ranged from city-level air quality indices to annual or daily pollutant concentrations. For example, in Sweden, Oudin et al. (2016) utilised long term exposure estimates for air pollutants, whereas Szyszkowicz et al. (2020) in Canada, focused only on the daily concentrations without emphasis on the duration levels.[33,38] The varied exposure measurement may contribute to heterogeneity in reported associations.

Secondly, the measurement of outcomes across studies also varied. For instance, Reuben et al. (2021) in the UK conducted structured interviews to evaluate psychopathology symptoms, whereas Smolker et al. (2024) utilised psychometric instruments to assess both internalizing and externalizing behaviours.[36,37] In contrast, research from Canada and Sweden relied on hospital or medication records, which provide a broader yet less detailed perspective.

Despite these caveats, the observed association can be explained with the basis of biological processes. The underlying mechanism for the association of air pollution and mental health is thought to stem from neuroinflammation and oxidative stress triggered by pollutants during critical periods of neurodevelopment which may lead to both structural and functional alterations in the developing brain.[40] The hippocampus and prefrontal cortex, which is the emotional regulation and decision-making region of the brain, are more susceptible to the changes caused by these pollutant-derived neuroinflammation.[40,41] Hence, prolonged exposure to pollutants increased the vulnerability of youth towards emotional dysregulation and cognitive decline.[41] These findings highlight the critical necessity for the implementation of policies aimed at reducing air pollution and safeguarding the mental health of youth.

Noise pollution and mental health

Noise pollution, on the other hand, was somewhat heterogeneous. Several studies associate short- and long-term noise exposure to depression, anxiety, distress and even an increased risk of suicide. However, not all studies showed significant effects. For instance, studies in Switzerland, UK, and Netherlands showed significant risk of distress, anxiety and suicide deaths following long-term noise exposure.[30,35,39] In contrast, Bloemsma et al. in Canada did not find significant association with youth mental wellbeing following prolonged noise exposure.[34] The inconsistencies in findings were reflected in the differences of noise characterisation, timing of exposure and outcome specificity across relevant studies. Short-term noise exposure however was more consistently associated with acute mental health symptoms. Increased risk of poor mental health, depression and anxiety among youth in Korea, Denmark and Germany were significantly associated with noise annoyance.[26,28,31,32]

The association between noise pollution and mental health in children and youth is hypothesised to be due to stress-response pathways. Prolonged exposure to noise has been shown to increase levels of stress hormones, including cortisol and adrenaline, which can disrupt normal physiological functions and heighten susceptibility to mental health issues associated with stress.[20,21] Furthermore, noise pollution negatively influences sleep quality, with nocturnal road traffic noise associated with increased hyperactivity and emotional instability among children.[21] The annoyance caused by noise can also further intensify these negative outcomes by inducing psychological distress and amplifying stress reactions.[42] These findings highlight the importance of implementing noise reduction strategies in urban development to protect the mental health of children and youth.

Trend in study findings

There are several notable trends that can be observed from the included studies. Primarily, PM2.5 emerged as the most studied pollutant, indicating its recognition as a significant public health issue. Additionally, studies often included Nitrogen dioxide (NO2) and nitrogen oxides (NOx), highlighting the role of vehicular and industrial emissions in worsening the mental health risks.

In regards to the study design, longitudinal studies were predominant, offering valuable insights into the effects of long-term exposure. Nevertheless, the findings of the cross-sectional and retrospective cohort studies provide important information on the acute and short-term impacts of air and noise pollution. The method of outcome assessment varied across studies. While some utilised structured interviews and psychometric instruments, such as the General Health Questionnaire (GHQ) or Child Behaviour Checklist (CBCL), others utilised the national or hospital data. This illustrates the relationship between detailed individual-level data and broader population trends.

Implications for Policy and Interventions

The strong evidence linking air and noise pollution to youth mental health outcomes warrants a proactive policy response especially on the need for enhanced urban planning, improved residential designs, and stricter regulations on industrial and vehicular emissions. Current frameworks from other regions provide valuable insights and models. For example, under the European Union (EU) zero pollution action plan adopted in 2021, the Ultra-Low Emission Zone (ULEZ) was implemented in London whereby drivers of vehicles that do not meet specific emission standards are charged a daily fee to drive in the designated ULEZ. This action has resulted to a 43% reduction in NO2 pollutants within a year.[43] Additionally, Sweden's comprehensive regulatory framework on emission control under the European Union's Ambient Air Quality Directive and land-use regulations have resulted in reduced NO2 levels in urban areas and keep the residential areas cleaner and quieter.[38,44] In Southeast Asia, public housing developments in Singapore are assessed for indoor air quality and ventilation quality under Green Mark certification scheme which limits the indoor sources of air pollution in housing infrastructure.[45]

For Malaysia, integrating environmental health into urban development strategies, such the National Physical Plan (NPP) and the Malaysia Urban Rural National Indicators Network for Sustainable Development (MURNInets), may facilitate the reduction of noise and air pollution. Potential strategies to alleviate the mental health effects of pollution on youth includes:

- Expanding the low-emission zones and green spaces adjacent to educational institutions and residential neighbourhoods;
- Enhancement of public transportation to diminish vehicle emissions; and
- Implementation of national air quality monitoring systems integrated with mental health surveillance and integrating mental health risk evaluations within Environmental Impact Assessments (EIAs) for urban development.

Additionally, public awareness initiatives aimed at youth and high-risk populations can enhance resilience. Overall, a unified strategy integrating urban planning, environmental regulation, and mental health policy is crucial to mitigate the enduring impacts of environmental stressors on the mental well-being of youth.

Limitations and way forward

Although this review provides important insights, the diversity in study designs, exposure assessments, and outcome evaluation limits direct comparability. Future research should focus on standardising methodologies and incorporating policy evaluations to better understand the impact of urban air and noise pollution on youth mental health. Notably. there is limited research on the combined effects of air and noise pollution, which is another important knowledge gap identified in this review. The simultaneous exposure to both pollutants creates a high-risk environment that may exacerbate the mental health effects associated with each pollutant individually. Moving forward, it is crucial for future studies to focus on the synergistic effects of air and noise exposure on mental health, as well as to explore the aspects of resilience that provide a protective effect against such exposures among youths. By prioritizing these areas of research, we can better understand the complex relationship between environmental exposures and mental well-being, ultimately leading to more effective public health initiatives and the creation of healthier urban environments for future generations.

CONCLUSION

The review highlights the urgent need to address environmental factors that impact the mental health of youth as a top public health priority. Noise and air pollution were shown to have significant effects on mental health in young populations, both through direct physiological impacts and socio-environmental interactions. These findings emphasize the importance of taking a proactive approach by incorporating environmental health strategies into mental health frameworks and promoting resilience in vulnerable communities. Collaborative efforts across research, policy, and practice are essential in order to reduce the impact of urban environmental stressors and enhance mental well-being among youth. Through sustained attention and intervention, public health systems can effectively address the challenges posed by urban pollution and youth mental health, ultimately leading to healthier and more equitable future.

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