



Climate change, ambient air pollution, and students' mental health

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Abstract

The impact of global climate change and air pollution on mental health has become a crucial public health issue. Increased public awareness of health, advancements in medical diagnosis and treatment, the way media outlets report environmental changes and the variation in social resources affect psychological responses and adaptation methods to climate change and air pollution. In the context of climate change, extreme weather events seriously disrupt people's living environments, and unstable educational environments lead to an increase in mental health issues for students. Air pollution affects students' mental health by increasing the incidence of diseases while decreasing contact with nature, leading to problems such as anxiety, depression, and decreased cognitive function. We call for joint efforts to reduce pollutant emissions at the source, improve energy structures, strengthen environmental monitoring and governance, increase attention to the mental health issues of students, and help student groups build resilience; by establishing public policies, enhancing social support and adjusting lifestyles and habits, we can help students cope with the constantly changing environment and maintain a good level of mental health. Through these comprehensive measures, we can more effectively address the challenges of global climate change and air pollution and promote the achievement of the United Nations Sustainable Development Goals.

Key Words: Climate change; Ambient air pollution; Mental health; Energy structure; Public policy; Sustainable development

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Core Tip: Global climate change and air pollution are becoming increasingly important issues in the field of public health and are exerting complex impacts on mental well-being. Extreme climate events and air pollution not only disrupt living environments, triggering the emergence of psychological conditions such as "ecological anxiety" but also exacerbate anxiety, depression, and other psychological problems. In response to this challenge, nations should begin to reduce pollutant emissions and improve energy structures, and society needs to strengthen environmental regulations and establish supportive public policies. Additionally, individuals should maintain good mental health and collectively contribute to achieving the United Nations Sustainable Development Goals.

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INTRODUCTION

To address a series of social, economic, and environmental issues faced worldwide, the United Nations has proposed the Sustainable Development Goals, which call for urgent action to address climate change and its impacts, ensure healthy lifestyles, and promote the well-being of people of all ages. The Sustainable Development Goals emphasize the urgency of maintaining the environment and human health at a global level. Recently, Hu *et al*[1] explored the impact of meteorological factors and air pollution on depression incidence. Their study revealed that both meteorological factors and the air pollutant nitrogen dioxide influence daily hospitalization rates among individuals with depression, and there is an interaction between meteorological factors and environmental air pollution. The findings of Hu *et al*[1] offer important references for further analyzing the relationships among climate change, environmental air pollution, and mental health.

In recent years, with the continuous increase in energy consumption and greenhouse gas emissions, air pollution has become more severe, and the climate is continually changing, leading people worldwide to increasingly suffer from the impacts of extreme weather events[2]. Issues such as resource scarcity, poor living conditions, and displacement are becoming increasingly prominent. In some areas, people suffer from serious disease due to environmental pollution, which not only causes considerable disturbances in their lives but also poses a great threat to their mental health. In the face of climate change and environmental issues, negative emotions such as depression, anxiety, and stress frequently occur. The learning environment of students is destabilized by extreme weather, physical health problems are caused by air pollution, and media reports on environmental pollution create a sense of existential crisis, leading to a continuous increase in psychological distress. These factors have a profound negative impact on students' daily academic lives. This has led to the realization that, in addition to traditional factors such as genetics[3], childhood environment[4], personal personality[5], and peer relationships[6], the impact of climate change and environmental air pollution on students' mental health cannot be ignored. How to maintain a healthy psychological state is currently a concern. A healthy psychological state can help students realize their personal potential, cope with various pressures in daily work and life, and reduce the adverse effects of negative emotions on the body[7]. Improvements in mental health can enhance people's quality of life, public health, and productivity[8]. Furthermore, students with good mental health are more likely to actively participate in social activities, which has a profound impact on social and economic development. Therefore, good mental health is very important for students' personal growth, economic progress, and sustainable social development.

THE IMPACT OF CLIMATE CHANGE ON MENTAL HEALTH

Global climate change, characterized by extreme weather events such as floods, droughts, hurricanes, and blizzards, leads to the destruction of living environments and poses threats to physical and mental health. Events such as injuries, deaths of loved ones, and illness increase the likelihood of mental disorders[9,10]. "Ecological anxiety" and "ecological grief" also affect people's mental health[11,12].

Different types of extreme weather events negatively impact mental health in varying ways. In the aftermath of floods or hurricanes, individuals are susceptible to illnesses such as colds, coughs, rashes, and gastrointestinal infections. From a neurobiological perspective, traumatic experiences associated with flooding can lead to overactivation of the brain's stress response system, impacting the long-term balance of neurotransmitters such as serotonin and norepinephrine[13,14]. Increasing environmental temperatures may lead to an increase in the incidence of personal attacks, homicides[15,16], and suicide[17]. In Bern, Switzerland, for every 10 °C increase in the average daily temperature due to global warming, the risk of mental health disorders increases linearly by 4%[18]. When the average Wet Bulb Globe Temperature index reaches 35 °C, overheating can occur in temperature-sensitive areas of the brain and thyroid hormones are inhibited, leading to functional hypothyroidism, which affects psychological functions and emotional regulation[19]. When temperatures exceed 26.7 °C, the number of hospitalizations for mental health disorders increases[20]. For people with existing mental health issues, heatwaves can exacerbate underlying psychiatric and behavioral disorders, increasing their risk of death by more than three times[21,22]. Research conducted by Hackbarth *et al*[23] demonstrated that individuals who

experience meteorological disasters often face drastic lifestyle changes and resource shortages. These challenges lead not only to a scarcity of material resources but also to a weakened sense of community belonging and disturbances in individual self-identity, thereby increasing the risk of posttraumatic stress disorder. Additionally, a study by Rataj *et al* [24] indicated that residents of low- and middle-income countries are more susceptible to the impacts of extreme weather events.

Moreover, extreme weather causes transportation difficulties, and restrictions on individual activities disrupt the normal lives and social activities of students, easily triggering anxiety and leading to a sense of social isolation. This anxiety and social isolation further exacerbate mental health issues[25]. The frequent occurrence of extreme weather events, which can be sudden and unpredictable, leads to uncertainty and fear about the future. This sense of hopelessness and powerlessness can lead to escapism, negatively impacting mental health. The environmental deterioration caused by climate change may force people to relocate, losing their original social networks and community ties[26], which leads to instability in students' learning environments and adversely affects their mental health.

THE IMPACT OF AMBIENT AIR POLLUTION ON MENTAL HEALTH

The detrimental effects of air pollution on mental health cannot be overlooked. Air pollution is currently one of the most impactful environmental health risks worldwide. It arises not only from industrial emissions and vehicle exhaust but also from agricultural activities and household burning. As a major environmental issue, air pollution substantially impacts people's physical and mental health[27]. The World Health Organization (WHO) reports that 91% of the global population lives in places where the air quality exceeds WHO guideline limits, with 4.2 million premature deaths caused by environmental air pollution. Air pollutants are considered one of the most critical risk factors affecting mental health [28].

On the one hand, air pollution contains numerous toxic substances, such as fine particulate matter (PM_{2.5}), NO₂, and SO_x, posing a direct threat to human health and leading to respiratory and cardiovascular diseases[29]. Epidemiological studies have shown that air pollutants such as PM_{2.5} and PM₁₀ are associated with an increased risk of mental health issues. Short-term exposure to these environmental particulates can lead to an increase in symptoms of mental health problems, such as depression and anxiety[30]. Particulate matter can travel through the respiratory tract to the brain, causing inflammation. This inflammation can lead to changes in brain activity and pathological function, ultimately affecting cognitive ability. Prolonged exposure to high concentrations of air pollution may cause neurodegenerative changes and increase the risk of mental and behavioral disorders[31]. Air pollution affects mental health levels by increasing the incidence and severity of diseases.

On the other hand, according to the biophilia hypothesis, humans have an inherent inclination to connect with nature and other life forms. In highly urbanized areas or environments that lack green spaces, air pollution reduces students' contact with nature, which may lead to issues such as anxiety, depression, and cognitive decline[32]. Due to limited outdoor activities, students' social interactions are impacted, which may lead to a decline in social skills, an increase in feelings of loneliness, and a weakening of community cohesion. This social isolation not only affects individuals' emotional states but can also impact the stability of social relationships. Regular physical activity has been suggested to have a positive effect on reducing anxiety and depression in students, as well as improving mood and self-esteem[33]. Air pollution also leads to a lack of regular physical exercise for many people, directly impacting their physical health and, consequently, their mental health. In addition to its general impact on students' mental health, air pollution has a more severe effect on specific groups. Men, rural residents, and individuals with lower income and education levels may be more susceptible to the negative effects of air pollution due to their specific socioeconomic status and environmental exposure[34,35]. Long-term exposure of children to pollutants can affect brain development and function, leading to learning disabilities, attention deficits, and memory loss[36]. The impact of air pollution on children may have adverse effects on the future education of the country.

CONCLUSION

With the current global trend of climate warming, we are facing an increasingly severe environmental and health crisis. To effectively address this global health crisis, it is imperative to take measures in the following areas to maintain students' mental health.

First, it is crucial to reduce pollutant emissions at the source, improve energy structures, enhance energy efficiency, and strengthen environmental monitoring and governance. The fundamental causes of meteorological changes and air pollution are the extensive greenhouse gas emissions generated during the industrialization process, mainly from burning fossil fuels. The urban heat island effect, exacerbated by rapid urbanization, also intensifies climate change. In daily life, the widespread use of private vehicles and the application of fertilizers and pesticides in agriculture contribute substantially to greenhouse gas emissions. Therefore, it is necessary to reduce pollutant emissions at their source; accelerate the transition from fossil fuels to renewable energy sources such as solar power, wind power, and hydropower; and promote high-quality socioeconomic development through green initiatives. Relevant societal sectors need to promote green building standards and technologies to reduce building energy consumption and mitigate the urban heat island effect while enhancing environmental monitoring and governance. Additionally, the public should be encouraged to increase their awareness of environmental protection, adopt healthier lifestyles, reduce greenhouse gas emissions, and implement more environmentally friendly production and consumption patterns to alleviate the negative impact of the

environment on mental health.

Second, attention must be given to students' mental health issues. By establishing public policies and strengthening social support, we can help students build resilience, reduce the psychological impact of climate change and environmental pollution and ensure students' growth and learning in a healthy environment. Public policies play a crucial role in increasing awareness of mental health and reducing environmental pollution. Additionally, social support systems are key for providing sociopsychological health services and maintaining individual mental health, assisting students in coping with psychological distress and enhancing overall mental well-being. Implementing material use interventions in educational environments can effectively alleviate mental health issues among students[37]. Support from families, friends, and communities can also help students cope with the stress and challenges brought about by environmental changes. A crucial aspect of addressing the potential negative psychological impacts of climate change is building resilience. Relevant authorities should guide professional rescuers to help students develop psychological resilience and utilize their social networks.

Finally, students need to adjust their lifestyles and habits to cope with the constantly changing environment and maintain a good level of mental health. Artificial intelligence-assisted screening for psychiatric risks can help students maintain sound mental health[38]. Good mental health enables students to adapt better to environmental changes. Individuals with healthy mental states are more adept at accepting lifestyle changes brought about by environmental degradation and maintaining a positive and optimistic attitude during the adaptation process. Mental health is closely linked to physical health, and physical exercise plays a vital role in maintaining mental well-being. Exercise not only increases hormone levels, such as those of endorphins and brain-derived neurotrophic factors, which reduce stress, but also helps alleviate mood disorders[39]. The maintenance and improvement of mental health are related to the intensity and frequency of physical exercise, and frequent high-intensity physical exercise is beneficial for maintaining mental health[40]. In adverse weather conditions, interactive sports games, such as simulated football, tennis, and running, can be played through electronic devices to maintain the continuity of physical activity. Moreover, maintaining normal social activities is equally important for students' mental health.

In summary, in the face of climate change and environmental challenges, maintaining and promoting individual mental health among students is crucial. Comprehensive measures are needed, ranging from reducing greenhouse gas emissions to providing mental health services. These actions are not only key to achieving students' mental health and well-being but also vital components of promoting overall sustainable social development. Through such integrated approaches, we can more effectively confront the challenges posed by global climate change and air pollution, fulfilling the vision of the United Nations Sustainable Development Goals related to health and climate action and thus contributing to building a healthier, more sustainable future.

FOOTNOTES

Author contributions: Liu XQ designed the study, and Liu XQ and Wang JX wrote the manuscript; All the authors contributed equally to this work and have approved the final manuscript.

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