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Article

Cold Spell and Mental and Behavioral Disorders: A Higher Risk from Higher Cold Spells' Intensity and Duration

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Abstract: Cold spells are increasingly recognized as important climate-related stressors for human health. However, evidence on the effects of cold spells on mental and behavioral disorders remains limited, particularly regarding how cold spells' intensity and duration influence hospitalization risk and whether the effects differ across disease types and population subgroups. We conducted a time-series study using the hospitalizations for mental and behavioral disorders in Hefei city of Anhui Province of China during the cold season (November to February) from 2016 to 2019. A cold spell was defined as daily mean temperature was below the 2.5th, 5th, or 7.5th percentile and lasted for at least 2–5 consecutive days. A total of 12 cold spell definitions were used. The distributed lag non-linear model combined with a generalized additive model was used to estimate hospitalization risk, with stratified analyses by disease subgroup and population characteristics. Cold spell was significantly associated with an increased risk of hospitalization for mental and behavioral disorders. Under the main cold spell definition (daily mean temperature below the 2.5th percentile for ≥3 consecutive days), the association was strongest among patients with schizophrenia [Relative risk (RR) = 1.75, 95% confidence interval (CI):1.50, 2.03)], while no statistically significant associations were observed for depressive disorder (RR = 0.92, 95%CI:0.64, 1.32) or bipolar disorder (RR = 1.03, 95%CI:0.76, 1.41). Stronger associations were observed among urban residents (RR = 2.41, 95%CI:2.09, 2.78) and individuals aged >42 years (RR = 2.11, 95%CI:1.83, 2.44). Notably, hospitalization risk of mental and behavioral disorders varied by cold spell's characteristics, with a higher risk associated with lower temperature threshold and longer cold spell duration. Results also remained robust across multiple sensitivity analyses. Cold spells are associated with increased hospital admissions for mental and behavioral disorders, with heterogeneous effects across disease types and population subgroups. These findings highlight the need to incorporate cold spell exposure into climate-related mental health risk assessment and prevention strategies.

Keywords: cold spell; mental and behavioral disorders; hospitalization; China

1. Introduction

Mental disorders have become an increasingly prominent global public health challenge. According to World Health Organization (WHO) data, approximately 1.095 billion people worldwide were affected by various types of mental disorders in 2021, accounting for about 14% of the global population [1]. Previous studies generally suggest that the onset and development of mental disorders result from the combined effects of multiple factors, including genetic susceptibility, socioeconomic factors, and psychological stress [2,3].

In recent years, environmental factors, particularly temperature, have been recognized as important but understudied risk factors for mental health [4–6]. To date, the existing literature has largely focused on the effects of high-temperature on psychiatric disorders. For example, a time-series study conducted in Hefei, China reported that elevated ambient temperature was significantly associated with increased hospital admissions for schizophrenia; specifically, exposure to 28 °C (75th percentile of temperature distribution) at lag 0–4 days corresponded to a 7% (95%CI:4–11%) increase in admissions [7]. By comparison, the effect of low temperature, especially extreme cold events such as cold spells has received less attention. Nevertheless, existing evidence suggests that exposure to cold spells may significantly increase the risk of adverse health outcomes related to mental illness. For instance, one study found that cold spell events increased the risk of hospitalization for schizophrenia by 8.1%; potential mechanisms may involve biological processes such as cold-induced stress responses and dysregulation of the microbiota-gut-brain axis. Additionally, certain antipsychotic medications may interfere with thermoregulatory functions, thereby exacerbating physiological stress in a cold environment [8].

Previous studies have shown that health effects of cold spells differs between urban and rural populations [9,10]. For instance, a study from Madrid indicates that urban people experience the greater cold-related mortality than rural people, suggesting that contextual factors such as population structure, housing conditions, and socioeconomic status to some extent shape population vulnerability to cold spells [11]. As these factors are also closely linked to mental health, the effects of cold spells on mental and behavioral disorders may be different between urban and rural areas [12,13]. However, urban-rural differences have rarely been explored in studies examining the association between cold spells and mental disorders. Furthermore, a study across multiple regions in China demonstrated that mortality rates significantly increased when cold spell duration and intensity escalated [14], indicating that cold spell-related health risks depend not only on the occurrence of low-temperature events but also closely correlate with their intensity and persistence characteristics. However, existing research has rarely compared the differential health impacts of cold spells with varying characteristics (e.g., intensity, persistence) on mental health.

Therefore, using hospitalization data for mental disorders from Anhui Mental Health Center in China, this study aims to quantify the short-term effects of cold spells on mental and behavioral disorders and to identify susceptible subpopulations. Importantly, considering that cold spells have different levels and may cause differential health effects [15], we also examined how cold spell's intensity and duration affected the effects of cold spells on mental and behavioral disorders, with the aim to assist in developing more effective prevention strategies.

2. Methods and Materials

2.1. Study Population and Outcomes

We obtained hospitalization records for mental and behavioral disorders from the Anhui Mental Health Center in China during the cold season (November to February) between 2016 and 2019. Based on the International Classification of Diseases, 10th Revision (ICD-10), we included patients with a primary diagnosis of mental and behavioral disorders (F00–F99). The outcomes were further classified into three diagnostic groups: schizophrenia (F20–F20.9), bipolar disorder (F30–F31), and depressive disorder (F32–F33, F34.1, F39). For each patient, we extracted basic demographic characteristics, including sex, age, and residential area, as well as the date of hospital admission.

2.1. Exposure Assessment

Daily mean temperature, relative humidity (RH), and atmospheric pressure were obtained from the European Centre for Medium-Range Weather Forecasts Reanalysis Fifth Generation dataset [16] with a spatial resolution of 9 km × 9 km. Air pollutant data, including daily mean concentrations of particulate matter (PM) with an aerodynamic diameter of 2.5 μm ($PM_{2.5}$) and nitrogen dioxide (NO_2), were obtained from the China National Environmental Monitoring Centre [17].

As there is no universally accepted definition of cold spells, we followed previous studies to define the cold spells based on both intensity and duration [18,19]. Specifically, we used the 7.5th, 5th, and 2.5th percentiles of daily mean temperature during the cold season (November to February) from 2016 to 2019 as temperature thresholds. A cold spell was defined as a period of at least 2, 3, 4, or 5 consecutive days with a daily mean temperature at or below the specified threshold (P7.5, P5, or P2.5). For example, P5_3d represents a cold spell defined as three consecutive days with a daily mean temperature at or below the 5th percentile. Based on this approach, a total of 12 cold spell definitions were constructed (Table 1).

To examine urban–rural difference in cold spell–related hospitalization risk for mental and behavioral disorders, we collected administrative division information from the Anhui Statistical Yearbook 2020 [20]. All residential areas were classified into two categories: urban areas (districts) and rural areas (townships and counties).

Table 1. Definition and number of cold spell days in Hefei, China during the cold seasons (November to February) from 2016 to 2019.

Name	Definition		Day(s)
	Percentile	Duration Day	
P2.5_2d	≤2.5th percentile of temperature	2	102
P2.5_3d	≤2.5th percentile of temperature	3	90
P2.5_4d	≤2.5th percentile of temperature	4	75
P2.5_5d	≤2.5th percentile of temperature	5	63
P5_2d	≤5th percentile of temperature	2	65
P5_3d	≤5th percentile of temperature	3	53
P5_4d	≤5th percentile of temperature	4	50
P5_5d	≤5th percentile of temperature	5	46
P7.5_2d	≤7.5th percentile of temperature	2	37
P7.5_3d	≤7.5th percentile of temperature	3	31
P7.5_4d	≤7.5th percentile of temperature	4	28
P7.5_5d	≤7.5th percentile of temperature	5	20

2.3. Statistical Analysis

Previous studies have shown that the health effects of cold spells [21,22] are often non-linear and delayed. Therefore, we applied DLNM [23,24] combined with a generalized additive model (GAM) to estimate the association between cold spell exposure and hospitalizations for mental and behavioral disorders during the cold season. The general model structure is presented as follows:

$$Y_t \sim \text{Poisson}\,(E(Y))$$

$$\text{Log}\,(E(Y)) = \alpha + \beta \times \text{Onebasis (cold spell)} + \text{NS(time, } df = 4\times\text{year)} + \text{NS(RH, } df = 3) + \text{NS}(PM_{2.5}, df = 3) + \text{DOW}$$

Daily counts of hospital admissions on day t were modelled using a standard time-series Poisson regression framework, which has been widely used in environmental epidemiology [25,26]. In the model, $E(Y)$ denotes the estimated daily number of hospital admissions, α is the intercept, and Onebasis (cold spell) represents the onebasis function for cold spell exposure. Day of the week (DOW) was included as an indicator variable. Following previous studies, ong-term trends and seasonality were controlled using a natural cubic spline (*ns*) of calendar time with 4 degrees of freedom (*df)* per year [27], with RH and $PM_{2.5}$ adjusted using splines with 3 *dfs* [28].

Residual autocorrelation was evaluated using the Ljung–Box test ($p = 0.22$), and no significant autocorrelation was detected. Additionally, we found overdispersion in the data and therefore attempted to apply a quasi-Poisson model for analysis. However, quasi-Poisson model produced wider confidence interval of RR estimates (e.g., All cases: quasi-Poisson: 95%CI:1.06–2.39; Poisson model: 95%CI:1.54–1.90). Meanwhile, to keep the consistency with previous studies [25,26], we therefore present the Poisson model results as the primary analysis.

In addition, we applied cross-basis functions for cold spells with varying maximum lags (2–4 days) to examine the lag effects of cold spells. We found that, except for lag 0, there were virtually no statistically significant effects at other lags (Table S1). Therefore, to ensure comparability across definitions, we specified the one-basis function at lag 0 as the primary effect estimate in the final model.

Based on comparisons of model fit using the Akaike Information Criterion (AIC) across different cold spell definitions, the P2.5_3d definition was selected for exposure assessment in subgroup analyses (Table S2). To identify potentially susceptible populations, we conducted stratified analyses by sex (male, female), age (younger

than the median age vs. the median age or older) [29,30], and residential area (urban, rural). Differences between stratum-specific effect estimates were assessed using the two-sample Z test [31].

To assess the robustness of our findings, several sensitivity analyses were performed. First, we adjusted the degrees of freedom (2–4) for the confounding factors ($PM_{2.5}$ and RH). Secondly, NO_2 and atmospheric pressure were added separately to the main model. Finally, in urban–rural stratified analyses, cold spell exposure was alternatively assigned using the city average temperature and area-specific average temperature for urban and rural areas.

All analyses were performed using R software (version 4.5.1), and a two-sided p value <0.05 was considered statistically significant.

3. Results

3.1. Descriptive Analysis

During the cold season (November to February) from 2016 to 2019, the 2.5th, 5th, and 7.5th percentiles of daily mean temperature in Hefei were −3.37 °C, −1.17 °C, and 0.12 °C, respectively. The number of cold spell days decreased with lower temperature thresholds and longer duration (Table 1).

A total of 9,472 hospital admissions for mental and behavioral disorders were included. The median age of the patients was 42 years, 50.52% were males, and 50.99% were urban residents. According to ICD-10, the primary diagnoses were schizophrenia, bipolar disorder, and depressive disorder, accounting for 46.08%, 13.78%, and 11.95% of all admissions, respectively (Table 2).

Table 2. Characteristics of the mental disorder patients in Hefei, China during the cold season (November to February) from 2016 to 2019.

Characteristics	Number (%)
All case	9472 (100%)
Diseases	
Schizophrenia	4365 (46.08%)
Bipolar disorder	1305 (13.78%)
Depressive disorder	1132 (11.95%)
Other diseases	2670 (28.19%)
Sex	
Male	4785 (50.52%)
Female	4687 (49.48%)
Urbanization of residence	
Urban	4830 (50.99%)
Rural	4642 (49.01%)
Age (year)	
≤42	4849 (51.19%)
>42	4623 (48.81%)

3.2. Association between Cold Spells and Mental and Behavioral Disorder Hospitalizations

Figure 1 presents the associations between cold spells and hospitalizations for total mental and behavioral disorders and different subgroups. Cold spell exposure was significantly associated with an increased risk of hospitalization for mental and behavioral disorders (RR = 1.71, 95%CI:1.54, 1.92). Among disease subgroups, the association was the strongest for schizophrenia (RR = 1.75, 95%CI:1.50, 2.03), whereas no statistically significant associations were observed for depressive disorder (RR = 0.92, 95%CI:0.64, 1.32) or bipolar disorder (RR = 1.03, 95%CI:0.76, 1.41).

In population subgroups, stronger associations were observed in urban residents (RR = 2.41, 95%CI:2.09, 2.78) and individuals aged >42 years (RR = 2.11, 95%CI:1.83, 2.44) ($p < 0.05$). Positive associations were observed in both male and female patients; however, differences between sexes were not statistically significant ($p > 0.05$) (Table S3).

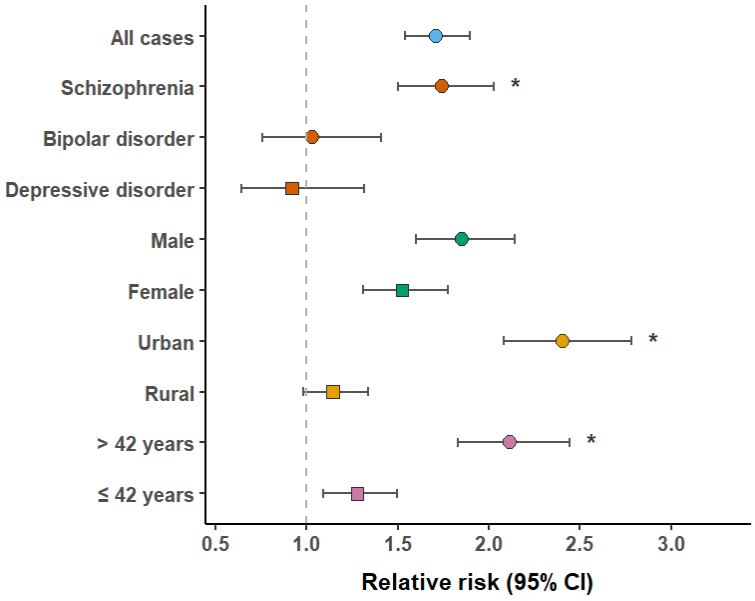

Figure 1. Estimated relative risks (RRs) of hospitalizations for mental and behavioral disorders associated with cold spells. Asterisk (*) indicates that the effect value is statistically significant. Square symbols represent reference groups.95%CI:95% confidence interval.

3.3. Associations of Cold Spells with Varying Intensity and Duration

Figure 2 further shows the associations of hospitalizations for mental and behavioral disorders with cold spells defined by different temperature thresholds and duration days. Overall, the risk increased with lower temperature thresholds and longer duration requirements. Specifically, the estimated RRs ranged from 0.93 (95%CI:0.88, 1.00) for the P7.5_2d definition to 1.76 (95%CI:1.57, 1.97) for the P2.5_4d definition. Owing to the limited number of events defined by the P2.5_5d criterion, no stable or statistically significant association was observed (Table S4).

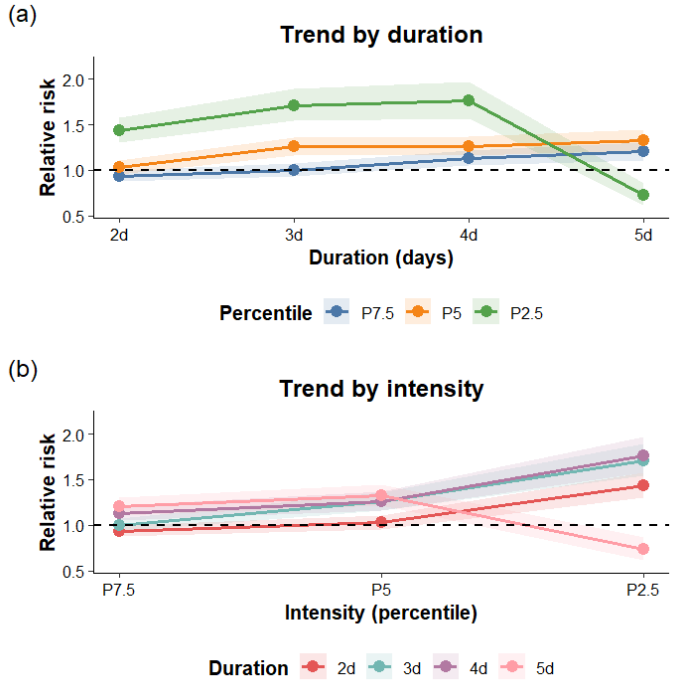

Figure 2. Relative risks (RRs) of hospitalizations for mental and behavioral disorders related to cold spells, by duration and intensity. (**a**) Risk trends for three cold spell intensity thresholds (P7.5, P5, and P2.5) across different durations (2–5 days). (**b**) Risk trends for cold-spell durations of 2–5 days across different intensity thresholds (P7.5, P5, and P2.5).

3.4. Sensitivity Analyses

In the sensitivity analysis, which included additional adjustment for NO_2 and atmospheric pressure (Table S5), varying the of *df* (2–4) for $PM_{2.5}$ and RH (Table S6), and using alternative exposure assignments based on city-wide average temperature and urban–rural area–specific average temperature (Table S7), the effect estimates varied numerically but the direction of the association remained generally consistent, indicating that the observed association is robust.

4. Discussion

Cold spells are associated with an increased risk of hospitalizations for mental and behavioral disorders, which aligns with previous evidence from China linking low ambient temperature to elevated admissions for mental and behavioral disorders, particularly among patients with schizophrenia [8,32,33]. Previous studies have proposed several biological mechanisms underlying this association. Early evidence from 1990 suggested that cold exposure may directly impact mental health by depleting a neurotransmitter named norepinephrine [34]. More recent studies have further confirmed that cold can become an important risk factor for triggering or exacerbating mental disorders through multiple mechanisms, including activation of the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system, causing neurotransmitter imbalance and proinflammatory immune status [35,36]. Additional research has indicated that cold may also stimulate the sensitization of the central nervous system, causing persistent inflammation [37], impairing prefrontal cortex function [38], and reducing neurotrophic levels [39], which then affects cognitive regulation. In the present study, these mechanisms provide a plausible explanation for the observed increase in hospitalizations during cold spell periods.

Notably, previous literature has also suggested that patients with schizophrenia may be more sensitive to cold environments. The underlying reason for this vulnerability is probably because the population's long-term use of antipsychotic drugs damages their ability to regulate their body temperature [40,41]. In addition, cognitive impairment may reduce the ability to actively take protective measures against cold exposure, such as wearing extra clothing or reducing outdoor activities, thereby further increasing cold-related health risks. The absence of significant associations for depressive disorders and bipolar disorders in our study may be due to limited statistical power, as fewer hospitalization cases could result in wider confidence interval of effect estimates. Alternatively, these disorders may be less sensitive to acute cold exposure, suggesting potential heterogeneity in temperature-related mental health effects across mental and behavioral disorders [42].

In addition to the overall association between cold spells and hospitalizations for mental and behavioral disorders, our stratified analyses showed a stronger association in the higher age group (aged >42 years). This finding is similar to the results from Jin et al. [43] and Pan et al. [32], also reporting adults aged ≥40 years as a susceptible population. The potential reason is that with the increase of age, the ability of temperature regulation gradually decreases [44], and the physiological adaptability to changes in ambient temperature weakens [45]. Moreover, a significant risk effect was observed in the urban subgroup in the present study, possibly because long-term exposure to heated indoor environments reduces adaptation to cold, resulting in stronger responses during cold spells. Additionally, urban residents may have better access to healthcare services and are more likely to seek hospital care, which could contribute to the higher observed admission rate [46]. Differences in built environment and housing quality between urban and rural areas may also influence actual cold exposure and lead to urban-rural difference in the effects of cold spells [47]. However, this result is inconsistent with Lavigne et al. [48], who found that urbanization did not significantly change the association between extreme temperatures and mental and behavioral disorders. Considering that this study is mainly based on a specific region, its generalizability and extrapolation require more evidence from different regions and climate backgrounds.

Other than identifying susceptible populations, this study also explored the impact of cold spells' characteristics on the risk of hospitalizations for mental and behavioral disorders. A key novelty of this work lies in the concurrent, rather than isolated, examination of cold spell's intensity and duration. Because cold spells are inherently defined by the combination of intensity and duration, analyzing either dimension separately may yield incomplete or biased estimates of the true health effects of cold spells [14]. The results showed that with the increase of cold spells' intensity and duration, the risk of hospitalizations for mental and behavioral disorders gradually increased, which is consistent with previous findings by Cohen et al. [49], Pan et al. [50], and Yoo et al. [51]. Stronger and longer cold exposure may maintain prolonged activation of the HPA axis and promoting inflammatory response. Moreover, prolonged and intense cold exposure may indirectly contribute to hospital admissions for mental and behavioral disorders through behavioral and social pathways, such as increased alcohol consumption [52], social isolation, delayed medical care, and a lack of healthy behaviors [53], thereby

exacerbating psychological distress and increasing the risk of hospitalizations due to mental and behavioral disorders.

Several limitations should be acknowledged. First, due to data availability, this analysis was conducted in a single city (Hefei). which may limit the generalizability of the findings to regions with different climatic conditions or health-care systems. Second, as the analysis was based on hospitalization data, the findings may primarily reflect more severe cases and may not generalize to milder cases. Third, cold spell exposure was defined using city-level daily mean temperature, which may not fully reflect individual-level exposure; so, exposure misclassification cannot be excluded, Finally, although we adjusted for long-term trend, seasonality, and multiple potential confounders, residual or unmeasured confounding (e.g., health-care accessibility or differences in disease severity) cannot be completely excluded.

5. Conclusions

This study indicates that cold spells are an important environmental exposure associated with hospitalizations risk for mental and behavioral disorders, with varying effects by disease types and population subgroups. Importantly, greater intensity and longer duration of cold spells represent a bigger threat in terms of hospital admissions for mental health conditions. Therefore, cold spells should be incorporated into assessments of climate-related hospital burden for mental and behavioral disorders and corresponding prevention strategies.

Supplementary Materials

The additional data and information can be downloaded at: https://media.sciltp.com/articles/others/260609175 6415864/ECDD-26030046-SI.pdf. Table S1: Estimated relative risks (RRs) for hospitalizations for mental and behavioral disorders across alternative cold spell definitions and lag period. Table S2: Akaike information criterion (AIC) values for models using different cold spell definitions. Table S3: Estimated relative risks (RRs) of hospitalizations for mental and behavioral disorders associated with cold spells. Table S4: Relative risks (RRs) of hospitalizations for mental and behavioral disorders associated with cold spells defined by different temperature thresholds and duration days. Table S5: Sensitivity analysis of the associations between cold spells and hospitalizations for mental and behavioral disorders after additional adjustment for NO2 and atmospheric pressure. Table S6: Sensitivity analysis of the associations between cold spells and hospitalizations for mental and behavioral disorders after changing the degree of freedom (*df*). Table S7: Sensitivity analysis of using city average exposure versus area-specific average exposure in regression model.

Author Contributions

Y.F.: data curation; formal analysis; writing—original draft. J.Y.: data curation; writing—original draft. R.T.: writing—original draft. Z.G.: writing—original draft. J.C.: project administration; resources; supervision; validation; funding acquisition; writing—original draft; & editing. All coauthors revised the manuscript together and approved the final version. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was approved by the Ethics Committee of Anhui Medical University (approval number: 81250374).

Informed Consent Statement

Not applicable.

Data Availability Statement

Daily mean temperature, relative humidity (RH), and atmospheric pressure were obtained from ERA5 dataset [https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land (10 March 2026)]. Air pollutant data, including daily mean concentrations of $PM_{2.5}$ and NO_2, were obtained from the China National Environmental Monitoring Centre [https://www.cnemc.cn/ (accessed 21 April 2026)].

Conflicts of Interest

The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

References

1. Taylor, L. One Billion People Have Mental Health Conditions, WHO Says. *BMJ* **2025**, *390*, r1860. https://doi.org/10.1136/bmj.r1860.
2. Arango, C.; Dragioti, E.; Solmi, M.; et al. Risk and Protective Factors for Mental Disorders beyond Genetics: An Evidence-based Atlas. *World Psychiatry* **2021**, *20*, 417–436. https://doi.org/10.1002/wps.20894.
3. O'Brien, K.J.; Huque, Z.M.; Pike, M.R.; et al. Synergistic Pathways to Psychosis: Understanding Developmental Risk and Resilience Factors. *Neuropsychopharmacology* **2026**, *51*, 273–292. https://doi.org/10.1038/s41386-025-02261-6.
4. Thompson, R.; Lawrance, E.L.; Roberts, L.F.; et al. Ambient Temperature and Mental Health: A Systematic Review and Meta-Analysis. *Lancet Planet. Health* **2023**, *7*, e580–e589. https://doi.org/10.1016/S2542-5196(23)00104-3.
5. Wang, H.; Fang, T. Cumulative Heat Exposure and Mental Health in Older Chinese Adults with Social Isolation Mediation. *Sci. Rep.* **2025**, *15*, 43470. https://doi.org/10.1038/s41598-025-27446-3.
6. Byun, G.; Choi, Y.; Foo, D.; et al. Effects of Ambient Temperature on Mental and Neurological Conditions in Older Adults: A Systematic Review and Meta-Analysis. *Environ. Int.* **2024**, *194*, 109166. https://doi.org/10.1016/j.envint.2024.109166.
7. Wang, S.; Zhang, X.; Xie, M.; et al. Effect of Increasing Temperature on Daily Hospital Admissions for Schizophrenia in Hefei, China: A Time-Series Analysis. *Public Health* **2018**, *159*, 70–77. https://doi.org/10.1016/j.puhe.2018.01.032.
8. He, Y.; Zhang, X.; Gao, J.; et al. The Impact of Cold Spells on Schizophrenia Admissions and the Synergistic Effect with the Air Quality Index. *Environ. Res.* **2022**, *212*, 113243. https://doi.org/10.1016/j.envres.2022.113243.
9. Hu, K.; Guo, Y.; Hochrainer-Stigler, S.; et al. Evidence for Urban-Rural Disparity in Temperature-Mortality Relationships in Zhejiang Province, China. *Environ. Health Perspect.* **2019**, *127*, 37001. https://doi.org/10.1289/ehp3556.
10. Wang, C.; Zhang, Z.; Zhou, M.; et al. Different Response of Human Mortality to Extreme Temperatures (MoET) between Rural and Urban Areas: A Multi-Scale Study across China. *Health Place.* **2018**, *50*, 119–129. https://doi.org/10.1016/j.healthplace.2018.01.011.
11. López-Bueno, J.A.; Navas-Martín, M.Á.; Díaz, J.; et al. The Effect of Cold Waves on Mortality in Urban and Rural Areas of Madrid. *Environ. Sci. Eur.* **2021**, *33*, 72. https://doi.org/10.1186/s12302-021-00512-z.
12. Clair, A.; Baker, E. Cold Homes and Mental Health Harm: Evidence from the UK Household Longitudinal Study. *Soc. Sci. Med.* **2022**, *314*, 115461. https://doi.org/10.1016/j.socscimed.2022.115461.
13. Cortina, J.; Hardin, S. The Geography of Mental Health, Urbanicity, and Affluence. *Int. J. Environ. Res. Public Health* **2023**, *20*, 5440. https://doi.org/10.3390/ijerph20085440.
14. Wang, L.; Liu, T.; Hu, M.; et al. The Impact of Cold Spells on Mortality and Effect Modification by Cold Spell Characteristics. *Sci. Rep.* **2016**, *6*, 38380. https://doi.org/10.1038/srep38380.
15. Ma, C.; Yang, J.; Nakayama, S.F.; et al. Cold Spells and Cause-Specific Mortality in 47 Japanese Prefectures: A Systematic Evaluation. *Environ. Health Perspect.* **2021**, *129*, 067001. https://doi.org/10.1289/EHP7109.
16. ERA5-Land Hourly Data From 1950 to Present. Available online: https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land (accessed 10 March 2026).
17. China National Environmental Monitoring Centre. Available online: https://www.cnemc.cn/ (accessed 21 April 2026).
18. Xu, R.; Huang, S.; Shi, C.; et al. Extreme Temperature Events, Fine Particulate Matter, and Myocardial Infarction Mortality. *Circulation* **2023**, *148*, 312–323. https://doi.org/10.1161/CIRCULATIONAHA.122.063504.
19. Hu, J.; Li, Z.; Zhu, J.; et al. Effect of Compound Exposure to Snowstorm and Cold Spell on Acute Myocardial Infarction Mortality. *Environ. Res.* **2025**, *272*, 121191. https://doi.org/10.1016/j.envres.2025.121191.
20. Anhui Provincial Bureau of Statistics. Anhui Statistical Yearbook 2020. Available online: https://tjj.ah.gov.cn/oldfiles/tjj/tjjweb/tjnj/2020/cn.html (accessed 22 April 2026).

21. Zheng, Y.; Xu, R.; Chen, Y.; et al. Opposite Interactive Effects of Heat Wave and Cold Spell with Fine Particulate Matter on Pneumonia Mortality. *Toxics* **2025**, *13*, 702. https://doi.org/10.3390/toxics13080702.
22. Guo, Y.; Barnett, A.G.; Pan, X.; et al. The Impact of Temperature on Mortality in Tianjin, China: A Case-Crossover Design with a Distributed Lag Nonlinear Model. *Environ. Health Perspect.* **2011**, *119*, 1719–1725. https://doi.org/10.1289/ehp.1103598.
23. Gasparrini, A. Distributed Lag Linear and Non-Linear Models in R: The Package Dlnm. *J. Stat. Softw.* **2011**, *43,* 1–20.
24. Gasparrini, A.; Armstrong, B.; Kenward, M.G. Distributed Lag Non-linear Models. *Stat. Med.* **2010**, *29*, 2224–2234. https://doi.org/10.1002/sim.3940.
25. Zhao, D.; Zhang, X.; Xie, M.; et al. Is Greater Temperature Change within a Day Associated with Increased Emergency Admissions for Schizophrenia? *Sci. Total Environ.* **2016**, *566–567*, 1545–1551. https://doi.org/10.1016/j.scitotenv.2016.06.045.
26. Li, H.; Zhang, S.; Qian, Z. et al. Short-Term Effects of Air Pollution on Cause-Specific Mental Disorders in Three Subtropical Chinese Cities. *Environ. Res.* **2020**, *191*, 110214. https://doi.org/10.1016/j.envres.2020.110214.
27. Guo, Y.; Gasparrini, A.; Li, S.; et al. Quantifying Excess Deaths Related to Heatwaves under Climate Change Scenarios: A Multicountry Time Series Modelling Study. *PLoS Med.* **2018**, *15*, e1002629. https://doi.org/10.1371/journal.pmed.1002629.
28. Ye, T.; Huang, W.; Xu, Z.; et al. Greenness and Hospital Admissions for Cause Specific Mental Disorders: Multicountry Time Series Study. *BMJ* **2025**, *391*, e084618. https://doi.org/10.1136/bmj-2025-084618.
29. McNeil, J.J.; Woods, R.L.; Nelson, M.R.; et al. Effect of Aspirin on Disability-Free Survival in the Healthy Elderly. *N. Engl. J. Med.* **2018**, *379*, 1499–1508. https://doi.org/10.1056/NEJMoa1800722.
30. McNeil, J.J.; Wolfe, R.; Woods, R.L.; et al. Effect of Aspirin on Cardiovascular Events and Bleeding in the Healthy Elderly. *N. Engl. J. Med.* **2018**, *379*, 1509–1518. https://doi.org/10.1056/NEJMoa1805819.
31. Lei, J.; Chen, R.; Liu, C.; et al. Fine and Coarse Particulate Air Pollution and Hospital Admissions for a Wide Range of Respiratory Diseases: A Nationwide Case-Crossover Study. *Int. J. Epidemiol.* **2023**, *52*, 715–726. https://doi.org/10.1093/ije/dyad056.
32. Pan, R.; Zhang, X.; Gao, J.; et al. Impacts of Heat and Cold on Hospitalizations for Schizophrenia in Hefei, China: An Assessment of Disease Burden. *Sci. Total Environ.* **2019**, *694*, 133582. https://doi.org/10.1016/j.scitotenv.2019.133582.
33. Zhong, Z.; Xu, J.; Liu, Z.; et al. The Impact of Different Types of Extreme Temperature Events on Mental Disorders: A Case-Crossover Study in Anhui Province, China. *Environ. Res.* **2025**, *277*, 121526. https://doi.org/10.1016/j.envres.2025.121526.
34. Rauch, T.M.; Lieberman, H.R. Tyrosine Pretreatment Reverses Hypothermia-Induced Behavioral Depression. *Brain Res. Bull.* **1990**, *24*, 147–150. https://doi.org/10.1016/0361-9230(90)90299-f.
35. Xu, B.; Zang, S.; Li, S.-Z.; et al. HMGB1-Mediated Differential Response on Hippocampal Neurotransmitter Disorder and Neuroinflammation in Adolescent Male and Female Mice Following Cold Exposure. *Brain Behav. Immun.* **2019**, *76*, 223–235. https://doi.org/10.1016/j.bbi.2018.11.313.
36. Baffi, J.S.; Palkovits, M. Fine Topography of Brain Areas Activated by Cold Stress. *Neuroendocrinology* **2000**, *72*, 102–113. https://doi.org/10.1159/000054577.
37. Girotti, M.; Donegan, J.J.; Morilak, D.A. Chronic Intermittent Cold Stress Sensitizes Neuro-Immune Reactivity in the Rat Brain. *Psychoneuroendocrinology* **2011**, *36*, 1164–1174. https://doi.org/10.1016/j.psyneuen.2011.02.008.
38. Modzelewski, S.; Naumowicz, M.; Suprunowicz, M.; et al. The Impact of Seasonality on Mental Health Disorders: A Narrative Review and Extension of the Immunoseasonal Theory. *J. Clin. Med.* **2025**, *14*, 1119. https://doi.org/10.3390/jcm14041119.
39. Değirmenci, M.D.; Çalışkan, H.; Güneş, E. Effects of Chronic Intermittent Cold Stress on Anxiety-Depression-like Behaviors in Adolescent Rats. *Behav. Brain Res.* **2024**, *472*, 115130. https://doi.org/10.1016/j.bbr.2024.115130.
40. Shiloh, R.; Weizman, A.; Epstein, Y.; et al. Abnormal Thermoregulation in Drug-Free Male Schizophrenia Patients. *Eur. Neuropsychopharmacol.* **2001**, *11*, 285–288. https://doi.org/10.1016/s0924-977x(01)00096-7.
41. Almendra, R.; Loureiro, A.; Silva, G.; et al. Short-Term Impacts of Air Temperature on Hospitalizations for Mental Disorders in Lisbon. *Sci. Total Environ.* **2019**, *647*, 127–133. https://doi.org/10.1016/j.scitotenv.2018.07.337.
42. Asimakopoulos, L.O.; Koureta, A.; Benetou, V.; et al. Investigating the Association between Temperature and Hospital Admissions for Major Psychiatric Diseases: A Study in Greece. *J. Psychiatr. Res.* **2021**, *144*, 278–284. https://doi.org/10.1016/j.jpsychires.2021.10.029.
43. Jin, J.; Xu, Z.; Cao, R.; et al. Long-Term Apparent Temperature, Extreme Temperature Exposure, and Depressive Symptoms: A Longitudinal Study in China. *Int. J. Environ. Res. Public Health* **2023**, *20*, 3229. https://doi.org/10.3390/ijerph20043229.
44. Ha, S.; Talbott, E.O.; Kan, H.; et al. The Effects of Heat Stress and Its Effect Modifiers on Stroke Hospitalizations in Allegheny County, Pennsylvania. *Int. Arch. Occup. Environ. Health* **2014**, *87*, 557–565. https://doi.org/10.1007/s00420-013-0897-2.
45. Ma, T.; Xiong, J.; Lian, Z. A Human Thermoregulation Model for the Chinese Elderly. *J. Therm. Biol.* **2017**, *70*, 2–14. https://doi.org/10.1016/j.jtherbio.2017.08.002.
46. Yan, Y.; Tu, Y. The Impact of China's Urban and Rural Economic Revitalization on the Utilization of Mental Health Inpatient Services. *Front. Public Health* **2023**, *10*, 1043666. https://doi.org/10.3389/fpubh.2022.1043666.
47. Sugg, M.M.; Stevens, S.; Runkle, J.D. Estimating Personal Ambient Temperature in Moderately Cold Environments for

Occupationally Exposed Populations. *Environ. Res.* **2019**, *173*, 497–507. https://doi.org/10.1016/j.envres.2019.03.066.
48. Lavigne, E.; Maltby, A.; Côté, J.-N.; et al. The Effect Modification of Extreme Temperatures on Mental and Behavior Disorders by Environmental Factors and Individual-Level Characteristics in Canada. *Environ. Res.* **2023**, *219*, 114999. https://doi.org/10.1016/j.envres.2022.114999.
49. Cohen, G.; Rowland, S.T.; Benavides, J.; et al. Daily Temperature Variability and Mental Health-Related Hospital Visits in New York State. *Environ. Res.* **2024**, *257*, 119238. https://doi.org/10.1016/j.envres.2024.119238.
50. Pan, R.; Wang, Q.; Yi, W.; et al. Temporal Trends of the Association between Extreme Temperatures and Hospitalisations for Schizophrenia in Hefei, China from 2005 to 2014. *Occup. Environ. Med.* **2021**, *78*, 364–370. https://doi.org/10.1136/oemed-2020-107181.
51. Yoo, E.; Eum, Y.; Gao, Q.; et al. Effect of Extreme Temperatures on Daily Emergency Room Visits for Mental Disorders. *Environ. Sci. Pollut. Res.* **2021**, *28*, 39243–39256. https://doi.org/10.1007/s11356-021-12887-w.
52. Carvalho, A.F.; Heilig, M.; Perez, A.; et al. Alcohol Use Disorders. *Lancet* **2019**, *394*, 781–792. https://doi.org/10.1016/S0140-6736(19)31775-1.
53. Zhang, S.; Yang, Y.; Xie, X.; et al. The Effect of Temperature on Cause-Specific Mental Disorders in Three Subtropical Cities: A Case-Crossover Study in China. *Environ. Int.* **2020**, *143*, 105938. https://doi.org/10.1016/j.envint.2020.105938.