1	Influence of Ambient Temperature on Emergency Psychiatric
2	Consultations: Evidence from an Emergency Setting in South America
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38 39	Abstract
40	Background: Although environmental factors have been studied for their impact on mental
41	health, the link between ambient temperature and mental disorders remains insufficiently
42	explored.
43	Aim: This study aimed to explore the relationship between ambient temperature and the
44	frequency of emergency psychiatric consultations at the sole university hospital in Paraguay from
45	2021 to 2023.
46	Methods: This investigation adopted a quantitative, observational, cross-sectional design, using

- 47 a case-crossover approach. Data collection entailed reviewing patient records and meteorological
 48 data, focusing on the daily mean temperatures and other meteorological variables. Statistical
- 48 data, focusing on the daily mean temperatures and other meteorological variables. Statistical 49 analysis was conducted using RStudio and SPSS, applying a distributed lag non-linear model
- analysis was conducted using RStudio and SPSS, applying a distributed lag non-linear model(DLNM) for a seven-day lag period. Multinomial logistic regression was used to estimate odds
- 51 ratios (ORs) for the likelihood of specific diagnoses resulting in emergency consultations in

52 relation to temperature exposure.

53 Results: The analysis covered 2,186 first-time emergency psychiatric consultations, with anxiety 54 disorders being the most frequent diagnosis (24.3%), followed by depressive disorders (23.4%) 55 and personality disorders (15.8%). Women accounted for 70.6% of all patients. The findings 56 indicated that higher temperatures were associated with a greater frequency of consultations for 57 certain disorders, including bipolar and eating disorders. Conversely, a negative association was 58 observed for schizophrenia, dissociative disorders, and trauma- and stressor-related disorders as 59 temperature increased. Additionally, a linear relationship was found between lower relative 60 humidity and increased number of consultations.

61 Conclusions: These results highlight the potential influence of ambient temperature on 62 emergency psychiatric consultations, revealing that the frequency of psychiatric consultations for 63 different conditions varies with temperature. These insights could inform public health strategies 64 in the strategies of the strategies

64 to mitigate the effects of climatic variation on mental health, particularly in resource-limited 65 settings.

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Keywords: Mental Disorders, Temperature, Psychiatric Emergency Services, Bipolar Disorder,
Anxiety, Humidity, Climate Change, Epidemiology, Public Health, Paraguay.

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70 Introduction71

Although various studies have explored the influence of environmental factors on mental health, such as climate change (1,2), the specific connection between ambient temperature and psychiatric morbidity remains an area requiring further investigation (3,4). Accordingly, understanding how ambient temperature impacts morbidity associated with psychiatric conditions in emergency departments can provide valuable insights into the interaction between climatic conditions and mental health outcomes (5,6).

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79 Previous research has highlighted that mental disorders significantly impact quality of life and 80 contribute substantially to the disease burden, particularly in low- and middle-income countries 81 (7-9), which are often vulnerable to the effects of climate change. Global estimates suggest that 82 the prevalence of mental disorders exceeds 17%, with notable variations across regions and 83 populations (10). Genetic predispositions (11), sleep quality (12), and social interactions (13) have 84 been linked to mental health outcomes. More recently, research has turned toward 85 understanding the role of environmental factors, including urbanization (14) and temperature 86 (15), in influencing mental health.

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Evidence suggests that high temperatures can exacerbate mental health issues, potentially through mechanisms involving heat stress and the resultant release of stress hormones, which may intensify mental and behavioral disorders (16). Contrastingly, low temperatures have been found to affect central nervous system function and lead to mental health disruptions (17). These findings indicate that the implications of temperature on mental health may differ owing to distinct physiological and psychological responses to heat and cold (18,19).

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95 The need for research in this area is underscored by observations during external events and 96 crises, such as the COVID-19 pandemic, which have significantly affected psychiatric consultations 97 and admissions. Notably, studies during the pandemic have reported an increased severity of 98 psychopathological conditions among individuals seeking psychiatric care (20,21). This 99 underscores the importance of examining how environmental stressors, including temperature, 100 interact with broader social and public health events to influence mental-health outcomes.

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102 Against this background, this study investigates how temperature variations influence the 103 frequency of emergency psychiatric consultations at a university hospital in Paraguay. Previous 104 research has highlighted the impact of climatic conditions on mental health; however, there is 105 limited knowledge about how temperature variations specifically affect psychiatric consultations 106 in emergency settings, especially in understudied regions such as South America. Accordingly, we 107 sought to broaden the understanding of how temperature fluctuations affect mental health and 108 to inform strategies for resource planning and public health interventions in similar settings.

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110 Methods 111

112 Design and sampling

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114 The study was structured as a quantitative, observational, and cross-sectional analysis, using a 115 retrospective temporal approach (22). It employed a case-crossover design with a distributed lag 116 non-linear model (DLNM) to provide a robust statistical framework for analyzing the temporal 117 relationships between temperature and the frequency of emergency psychiatric consultations. 118 Rather than sampling, the study included all available psychiatric consultations and 119 meteorological data within the defined timeframe from January 2021 to December 2023. 120 Importantly, this study did not measure the incidence of disorders but instead focused on the 121 association between climate conditions and the frequency of psychiatric consultations.

- 122123 Participants
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This study focused on first-time patients diagnosed with mental disorders during their initial emergency psychiatric consultation at the Hospital de Clínicas of the National University of Asunción (Paraguay) within the specified period. The accessible population included adult patients aged 18 years or older of both genders who visited the psychiatric emergency department for the first time within the study timeframe. The inclusion criteria required complete clinical records relevant to the variables of interest, thereby excluding cases with incomplete data.

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133 Variables and measures

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The variables analyzed included demographic characteristics, such as age (in completed years) and gender (male and female). Diagnoses were grouped according to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition, Text Revision (DSM-5-TR) (23). The meteorological variables analyzed included daily mean temperature (°C), mean atmospheric pressure (hPa), total precipitation, relative humidity, and sunshine duration, to assess their potential impact on psychiatric consultations.

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142 Data collection involved reviewing patient records using a digital data form and obtaining 143 meteorological information from the Paraguayan Directorate of Meteorology and Hydrology 144 (DMH), the national authority responsible for monitoring, analyzing, and disseminating 145 meteorological and hydrological data in Paraguay. Temperature values were represented by 146 percentiles (i.e., 5–95% in 5% increments) to capture a comprehensive range of observed thermal 147 conditions. These percentiles allowed for a wide and representative view of temperature 148 conditions during the study period. Subsequently, the temperature values were integrated into 149 the cumulative OR dataset to evaluate variations in ORs across different temperature levels, 150 providing a context for visualizing cumulative ORs against a spectrum of representative study 151 temperatures and facilitating interpretation through comparative graphical analysis.

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153 Data analysis

Data were entered into a spreadsheet and processed using the Statistical Package for the Social Sciences (SPSS), version 29, to perform descriptive statistics, including measures of central tendency, dispersion, and frequency tables. Further statistical analysis was conducted using RStudio version 2024.04.2+764, where a time-stratified case-crossover design was applied along with DLNM to evaluate the temperature's impact over a seven-day lag period. Pearson's correlation coefficient was used to assess the association between the monthly consultation counts and climate indicators.

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Multinomial logistic regression was used to estimate odds ratios (ORs) for the likelihood of specific diagnoses resulting in emergency consultations in relation to temperature exposure, adjusting for potential confounders such as age and gender. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to interpret the magnitude and direction of the association, where ORs greater than 1 indicated an increased likelihood in the frequency of emergency consultations for specific diagnoses, and ORs below 1 suggested a decreased likelihood. Quality control measures were implemented to exclude missing and outlier data.

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171 Ethical considerations

This study was conducted within the framework of the Scientific Research Improvement Program of the Research Group on Epidemiology of Mental Disorders, Psychopathology, and Neurosciences and was approved by the Department of Medical Psychology of the School of Medical Sciences at the National University of Asuncion, Paraguay (Ref. No. 007-009-2024). The data were treated with confidentiality, equality, and justice, in accordance with the Helsinki principles.

180 Results

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182 In total, 2,186 first-time psychiatric diagnoses made during the initial emergency consultations 183 were recorded between January 2021 and December 2023. The age range of these patients was 184 18-95 years, with a mean age of 35 years (± 15 years) and a median age of 30 years. The most 185 common age group was 23 years. Women comprised 70.6% of the sample and 75.4% of the 186 patients were residents of Greater Asunción (cities surrounding the country's capital city, 187 Asunción).

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189 The most frequently diagnosed group was the anxiety disorder group, accounting for 24.3% of 190 cases. Other significant diagnoses included depressive (23.4%), personality (15.8%), and 191 schizophrenia spectrum disorders (10.3%). Table 1 provides a detailed breakdown of the patient's 192 characteristics and diagnosis frequencies.

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Table 1. Demographic and diagnostic distribution of patients (N=2186).

Characteristics		%
Age		
≤ 20	304	13.9
21 - 45	1390	63.6
46 - 70	432	19.8
71+	60	2.7
Gender		
Female	1543	70.6
Male	643	29.4
Place of origin		
Asunción	335	15.3
Greater Asunción	1649	75.4

Rest of the country		9.3
Diagnosis		
Anxiety disorders	531	24.3
Depressive disorders	512	23.4
Personality disorders	345	15.8
Schizophrenia spectrum disorders	225	10.3
Bipolar and related disorders	183	8.4
Trauma- and stressor-related disorders	166	7.6
Substance-related disorders	89	4.1
Neurocognitive disorders	40	1.8
Dissociative disorders	32	1.5
Neurodevelopmental disorders	19	0.9
Sleep-wake disorders	15	0.7
Disruptive, impulse-control disorders	11	0.5
Obsessive-compulsive and related disorders	9	0.4
Somatic symptom and related disorders	7	0.3
Feeding and eating disorders		0.1

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197 The average daily temperature during the study period ranged from 6.72°C to 35.5°C, with a mean

198 of 22.74°C (± 5.39°C). Figure 1 illustrates the monthly distribution of the mean temperatures 199 across the study period.

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A linear relationship was observed between the number of consultations and relative humidity, with lower relative humidity corresponding to an increase in emergency psychiatric consultations across all diagnoses (r = -0.519, p = 0.002). No other significant correlations were observed. Additional comparisons are presented in Figure 2.





Figure 2. Correlation matrix of climate indicators and psychiatric consultation count.

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The temperature on the day before the consultation was positively associated with emergency 218 consultations for bipolar and eating disorders, indicating that higher temperatures corresponded 219 with an increased frequency of these diagnoses. In contrast, conditions such as schizophrenia, 220 dissociative disorders, and trauma- and stressor-related disorders showed a negative association, 221 with higher temperatures linked to fewer consultations. The findings also revealed that elevated 222 temperatures over the three days preceding consultations were associated with more frequent 223 consultations for bipolar disorders, depressive disorders, and disruptive impulse-control 224 disorders, while consultations for anxiety and sleep-wake disorders decreased. Additionally, 225 higher temperatures over the past seven days were associated with more frequent consultations 226 for anxiety and somatic symptom disorders but were inversely related to consultations for 227 bipolar, dissociative, neurocognitive, and trauma- and stressor-related disorders. Table 2 228 presents the results. Notably, raw temperature data were used without transformation. Although 229 the OR values may appear high, the main focus of this analysis was on whether they were greater 230 or less than 1.

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Table 2. Cumulative impact of mean temperature over seven days on psychiatric emergency consultation diagnoses.

OR (IC 95 %) Diagnoses Lag 1 Lag 3 Lag 7 Bipolar and related disorders 27.12(1.31-100) 100(5.71-100) 0.02(0.01-0.97) Anxiety disorders 100(0.05-100) 0.01(0.01-0) 100(1260.51-100) Feeding and eating disorders 100(4.68-100) 0.01(0.01-3.16) 0.03(0.01-100) Personality disorders 0.27(0.01-100) 0.67(0.01-100) 24.55(0.03-100) Somatic symptom and related disorders 18.11(0.07-100) 100(0.18-100) 100(7.88-100) Schizophrenia spectrum disorders 0.01(0.01-0.62) 0.13(0.01-100) 1.09(0.01-100) Neurodevelopmental disorders 15.71(0.01-100) 0.28(0.01-100) 0.01(0.01-1.42) Sleep-wake disorders 100(0.05-100) 0.01(0.01-0.07) 67.77(0.01-100) Depressive disorders 1.03(0.01-100) 100(6560.47-100) 6.95(0.01-100) Dissociative disorders 0.01(0.01-0) 0.05(0.01-35.8)0.01(0.01-0.06) Disruptive, impulse-control disorders 6.25(0.24-100) 100(39.58-100) 2.96(0.02-100) Neurocognitive disorders 2.52(0.01-100) 0.04(0.01-100) 0.01(0.01-0) Substance-related disorders 0.99(0.93-1.06) 1.07(1-1.14)1.03(0.96-1.11) Trauma- and stressor-related disorders 0.01(0.01-0) 0.73(0.1-5.37)0.23(0.06-0.89)

Lag: delay. Lag 1: likelihood of emergency consultation for a specific diagnosis based on temperature from the previous day. Lag 3: likelihood three days prior. Lag 7: likelihood seven days prior. OR: Odds ratio, CI: confidence interval. Bold values: p<0.05. The reference diagnosis was obsessive-compulsive disorder, selected by default by the analysis software package used.

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240 Higher odds ratios (ORs) indicated that specific diagnoses were more likely to result in an 241 increased frequency of emergency consultations as temperatures increased. For instance, the OR 242 for bipolar disorder rose with higher temperatures, suggesting heightened susceptibility to 243 consultation during warmer periods. In contrast, the ORs for schizophrenia and trauma-related 244 disorders decreased as temperatures rose, implying a reduced frequency of consultations for 245 these conditions in warmer weather. Figure 3 provides a visualization of the cumulative ORs for 246 various diagnoses influenced by temperature, illustrating how the likelihood of consultations 247 varies with temperature. Wider and higher areas indicate a stronger association, whereas flatter 248 or lower areas reflect a weaker relationship.

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- Figure 3. Visualization of cumulative ORs for emergency psychiatric consultation diagnoses in response to temperature variation.



274 Discussion

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Our results report on the relationship between climatic factors and the frequency of psychiatric consultations, underlining the important role of temperature and relative humidity. The finding that anxiety disorders were the most common reason for consultations among the 2,186 cases aligns with the existing literature, which emphasizes the growing prevalence of anxiety (24). Notably, for example, a systematic review and meta-analysis demonstrated a clear association between warm climates and adverse mental health outcomes including anxiety disorders (19).

- This correlation in the results is particularly relevant, considering that the majority of patients in this study were young adults with a mean age of 35 years, most of whom were women. This demographic trend aligns with findings from other studies, which indicate that younger populations, particularly women, are more susceptible to anxiety disorders (25,26). Similar geographic influences were explored in a case-crossover study in subtropical cities, revealing that local climatic conditions significantly affected the prevalence of specific mental disorders (27).
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A linear relationship was found between the number of consultations and relative humidity,
 where lower humidity levels were correlated with more mental health consultations. This finding
 is consistent with research suggesting that extreme climatic conditions, including low humidity,
 can exacerbate mental health problems (28).

294 The negative relationship between higher temperatures and consultations for schizophrenia and 295 dissociative disorders suggests that, while some conditions may lead to increased likelihood of 296 consultation in warmer weather, others may be less affected or respond differently. For instance, 297 a study conducted in Hefei from 2013 to 2019 examined the impact of cold spells on 298 schizophrenia admissions along with their interaction with the air quality index, finding that cold 299 spells significantly increased the risk of schizophrenia admissions. While that study examined 300 hospital admissions and the present work focuses on emergency consultations, this comparison 301 highlights the importance of adapting regional definitions of cold spells and timing precautionary 302 measures for vulnerable populations (29). In particular, lower temperatures can affect 303 psychological well-being and exacerbate symptoms in individuals predisposed to mental 304 disorders, including schizophrenia. Specifically, thermal stress, whether due to cold or heat, can 305 have adverse effects on mental health, suggesting that extreme climatic conditions could be a 306 risk factor for the development or exacerbation of schizophrenia symptoms (29). Thus, it is 307 plausible that cold temperatures, by disrupting emotional balance and cognitive functioning, 308 could contribute to an increase in the frequency of consultations related to schizophrenia, 309 although further research is required to clarify this relationship and any causal pathways.

310 The cumulative effects of temperature on various mental disorders indicate that higher 311 temperatures in the preceding days were associated with an increased frequency of emergency 312 consultations for bipolar and depressive disorders, while consultations for anxiety and sleep-wake 313 disorders decreased. This temporal aspect of the relationship between temperature and mental 314 health is fundamental because it suggests that immediate climatic conditions can have a direct 315 impact on emergency psychiatric consultations. These findings align with previous research 316 identifying acute climate changes as a trigger for mood disorders, particularly bipolar disorder 317 (30,31). Equally, our findings correspond with prior research conducted in Latin America, such as 318 the study by Corvetto et al. (2023) in Curitiba, Brazil, which observed a significant increase in 319 emergency department visits related to mental health during extreme heat (32). This work 320 reported that the relative risk of emergency visits for conditions like suicide attempts and 321 neurotic disorders notably increased, especially among women and individuals aged 18 to 64. 322 These results suggest that specific demographic subgroups are particularly vulnerable to high 323 temperatures, echoing the trends observed in our findings (32). This evidence exemplifies the 324 importance of adaptation policies and the implementation of early warning systems that could 325 mitigate the impact of heat on mental health and reduce the burden on public health services. 326 Furthermore, it highlights the need to identify and protect the most susceptible populations by 327 developing targeted interventions that enhance their resilience to extreme heat events.

328 The association between increased ambient temperatures and consultations for depression has 329 been widely studied, suggesting that extreme weather conditions negatively impact emotional 330 well-being, contributing to an increase in consultations for mood disorders, including depression 331 (33). Furthermore, systematic reviews have shown significant associations between elevated temperatures and negative mental health outcomes such as increased morbidity and mortality related to psychiatric conditions (34). Research indicates that extreme temperatures may disrupt the regulation of the autonomic nervous system, thereby increasing the risk of depression (35). Climate variations, such as extreme heat, can exacerbate the symptoms of depression and anxiety, affecting sleep quality and overall alertness (36).

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338 The observed relationship between higher temperatures and anxiety-related emergency 339 consultations supplements studies suggesting that facial skin temperature can serve as a 340 significant predictor of perceived anxiety, indicating that thermal variations may directly influence 341 emotional perception and anxiety levels (37). Moreover, Mittal et al. emphasized the importance 342 of personalized treatment strategies for patients with bipolar disorder who exhibit seasonal 343 symptoms, noting that fluctuations in temperature and daylight can provoke significant mood 344 changes (38). Bipolar II disorder, characterized by depressive episodes, is particularly sensitive to 345 seasonal shifts, reinforcing the idea that ambient temperature may influence the onset and 346 severity of mood episodes (38).

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Beyond the direct effects of temperature and light, understanding the biological mechanisms behind these relationships is essential. The role of melatonin, a hormone regulated by light exposure, is important in this context. Melatonin affects circadian rhythms and is associated with mood regulation (39). Alterations in melatonin levels due to seasonal changes can disrupt sleep patterns and worsen mood disorders, including bipolar disorder (40).

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354 Finally, the positive correlation between higher temperatures and increased frequency of 355 emergency consultations of eating disorders suggests that climatic conditions may influence 356 eating behaviors and body image perception. This has been identified in prior investigations 357 exploring the psychosocial impacts of temperature on eating behavior, suggesting that extreme 358 heat can alter appetite and food choices, potentially worsening existing eating disorders (41). 359 Extreme heat can induce physiological changes that may exacerbate symptoms of eating 360 disorders. For instance, high temperatures can disrupt the body's hormonal balance, particularly 361 hormones related to appetite and metabolism. Studies have shown that heat exposure can 362 increase levels of cortisol, a stress hormone that influences eating behaviors and perceptions of 363 body image (42,43). Further research is needed to clarify how stress, including environmental 364 stressors like heat, may lead to maladaptive eating behaviors, such as binge eating or restrictive 365 eating, potentially exacerbated by the discomfort and reduced appetite often associated with 366 heat exposure.

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368 Strengths and limitations

A major strength of this study was the use of comprehensive raw temperature data, which allowed for an unfiltered analysis of its impact on emergency psychiatric consultations. The casecrossover design with the DLNM provided a robust framework to capture the delayed and cumulative effects of temperature over time. Conducting the study in a university hospital in Paraguay added a unique, region-specific perspective to the global literature, addressing gaps in research on South America.

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However, this study has several limitations. Firstly, the reliance on data from a single hospital limits the generalizability of our findings to other regions or healthcare systems. Additionally, the higher proportion of consultations from the Greater Asunción area likely reflects the hospital's accessibility to this population due to its proximity and better access to mental health services compared to more remote regions, which may affect the applicability of our findings to other areas. The overrepresentation of women in the sample could also have influenced the generalizability of the findings, as gender differences could affect psychiatric consultation 384 patterns. The observed gender difference in consultation frequency may reflect differing patterns 385 in help-seeking behavior or varying levels of vulnerability to temperature-related stress across 386 genders. Further research is needed to explore these dynamics and their influence on 387 consultation patterns. Another limitation of this study is the use of obsessive-compulsive disorder 388 (OCD) as the reference diagnosis in the analysis. This selection was based on the default setting 389 of the analysis software package rather than a specific theoretical or clinical rationale. Using OCD 390 as reference may influence the comparative interpretation of results across diagnoses, as it may 391 not be the most representative baseline category, especially given its lower prevalence rates 392 compared to other disorders (44). Future studies could explore alternative reference diagnoses 393 to assess potential variations in findings. Additionally, the absence of categorizations for extreme 394 temperature highs and lows and the use of only daily mean temperatures restricted the depth of 395 analysis. Furthermore, potential biases in clinical records due to incomplete data were 396 acknowledged. It is also important to consider that a significant portion of the sample was from 397 the COVID-19 pandemic period, which may bias the frequency and nature of psychiatric 398 emergency consultations. Future research should include multiple healthcare centers and more 399 detailed temperature data to strengthen our findings. A broader range of environmental factors, 400 such as wind speed, should be incorporated to provide a more comprehensive understanding of 401 the climatic influences on mental health.

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403 Implications and future perspectives

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405 The findings in this study are significant for public health and clinical practice. Mental health 406 services could prepare for an influx of consultations during extreme temperature periods by 407 increasing staff and resources. Furthermore, public awareness campaigns could help inform the 408 community and healthcare providers of the potential mental health risks associated with 409 temperature fluctuations and enhance preventive measures. Further exploration of biological 410 and psychological mechanisms, such as the role of stress hormones and the autonomic nervous 411 system, is warranted. Future studies should address these limitations by including data from 412 multiple healthcare centers and incorporating more detailed temperature categorization. 413 Utilizing multicenter approaches and longitudinal designs could enhance the generalizability and 414 depth of the findings.

415 Conclusions

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417 This study highlights the significant impact of ambient temperature and relative humidity on 418 emergency psychiatric consultations, with distinct variations observed across different mental 419 disorders. Our findings underline the importance of public health strategies that incorporate 420 environmental factors in mental health resource planning, particularly to address observed 421 variations in consultation frequency under different climate conditions. While higher 422 temperatures were associated with an increased frequency of consultations for bipolar, 423 depressive, and eating disorders, lower relative humidity was linked to a general rise in mental 424 health consultations. These insights are particularly relevant in the context of global climate 425 change, which may amplify the demand for mental health resources in vulnerable regions. 426 Continued work in this area could yield valuable insights for adapting mental health services to 427 evolving environmental challenges. Future research should expand on these results by including 428 data from multiple centers and incorporating additional climatic variables to better understand 429 the complex relationship between environmental conditions and mental health. Ultimately, these 430 insights can contribute to the development of targeted and effective mental health strategies in 431 regions affected by climate variability, which is increasingly becoming a truly global concern.

432 Authors' contributions statement

J.T., M.L., A.P., I.B.: Conception and design of the study, analysis, and interpretation of results,
manuscript drafting. M.O., A.D.T-R., T.C.R., A.V., J.M.C-M., J.E-K, E.C., M.L., A.S., R.T., A.J., D.B.:
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