STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	retrospective observational study
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Background: It addresses the public health challenges faced by urban areas like Paris, particularly during heatwave occurrences, emphasizing the lack of research at the intersection of heatwaves, environmental variables, and demographic factors in dense urban settings. Methods: The study employed a retrospective methodology, gathering extensive data from the National Health Data System and the Technical Agency for Information on Hospitalization, covering 471,814 hospital stays from June to September over 2009 to 2019. Hospitalizations were categorized into ten clusters representing various medical conditions, with heatwave days identified using a percentile-based approach. The analysis

				used mixed-effects log-linear regression models to explore the correlations between hospitalization rates and various factors. Results: The analysis included data on 2,184,193 residents across 20 districts in Paris, highlighting the significant impact of age, especially the over-75 demographic, on hospitalization rates, alongside environmental metrics like peak temperatures and the FDEP15 index. Conclusions: The study concludes that the complex interplay of demographics, environmental stimuli, and heatwave events significantly shapes public health outcomes in Paris, underscoring the need for tailored healthcare interventions to address the vulnerabilities of the elderly population in the face of escalating climate crises.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3	Climate change is increasingly

				recognized as a multi-faceted global emergency with wide-ranging repercussions, not least of which is its profound impact on human health. Among the various settings affected, urban environments are particularly vulnerable due to their density and infrastructure. Paris offers a compelling case study in this context, characterized by a modified oceanic climate and experiencing temperature fluctuations that can reach extreme levels, thereby amplifying specific health risks such as dehydration, heatstroke, and cardiovascular complications. These adverse health effects are corroborated by a growing body of global data, reinforcing the urgency of addressing climatic shifts as a public health imperative.
Objectives	3	State specific objectives, including any prespecified hypotheses	4	Given the complex interplay between climate change and public health (10), this study aims to address the existing academic gap by offering a nuanced examination of the synergistic effects of heatwaves, environmental factors, and

				demographic variables on healthcare needs in Paris. Specifically, the study will delve into hospitalization rates as a key indicator of healthcare burden. It will explore how extreme weather conditions interact with other variables such as age demographics, building infrastructure, and the prevalence of air conditioning systems to influence health outcomes among Parisian residents.
Methods				
Study design	4	Present key elements of study design early in the paper	5	The study design is outlined early in the paper, detailing a retrospective observational study framework. This design is crucial for analyzing past hospitalization data related to heatwaves in Paris, utilizing extensive datasets from established healthcare databases. Key elements, such as the study's focus on hospitalization rates, the identification of heatwave days via climatic data, and the employment of mixed-effects log-linear regression models for

				data analysis, are introduced early to provide readers with a clear understanding of the research methodology and objectives.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5	Our research utilized comprehensive healthcare data from the National Health Data System (SNDS) and the Technical Agency for Information on Hospitalization (ATIH), focusing on hospitalizations from June to September 2009 to 2019 in Paris. The study population included data on 471,814 hospital stays, reflecting the pre-COVID-19 period and exclusively derived from the Paris department. We categorized hospitalization reasons using ICD-10 codes and analyzed environmental data, including temperature records from Météo France, to determine heatwave days using a percentile-based approach. This period was chosen due to its relevance to peak temperature highs in France, crucial for studying heatwave impacts on healthcare needs.

Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5	In our research, we utilized a comprehensive healthcare data approach, analyzing 471,814 hospital stays from June to September over the years 2009 to 2019, which were derived exclusively from the Paris department. The study focused on a retrospective analysis of hospitalization data during heatwaves, categorizing hospitalization reasons using specific codes and assessing various factors like demographic variables and environmental conditions. While this methodological approach differs from a case-control study, it provides a robust framework for examining the impacts of heatwaves on hospitalizations in Paris.
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		that the study design does not include matched cohorts or case-control pairs and is instead a retrospective observational study focusing on hospitalization data related to heatwave exposure without using a matching framework
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6	The study employed comprehensive healthcare data

				to analyze the impact of heatwaves on hospitalizations in Paris, focusing on various health outcomes like mental health disorders, heatstroke, diabetes, etc. The variables defined in the study include outcomes (hospitalization reasons), exposures (heatwave days, maximum temperature), predictors (% of population aged 75 and older, % of air conditioning, % of elevators), and potential confounders (FDEP15 Index, % of buildings aged over 75 years). These were analyzed using mixed-effects log-linear regression models to investigate the relationships between hospitalization rates and these variables.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*5*	In our research, we employed a comprehensive healthcare data approach, drawing from vital sources like the National Health Data System (SNDS) and the Technical Agency for Information on Hospitalization (ATIH). Our primary focus centered on extracting insights from the Program for Medicalization of Information

		Systems (PMSI) tables, providing detailed information about hospitalizations linked to heatwaves. Impressively, our dataset encompassed a substantial (471814) hospital stays spanning from June to September over the years 2009 to 2019, representing the pre-Covid-19 period. Importantly, this dataset was exclusively derived from the Paris department.
	5	Subsequently, we examined specific districts within Paris, supplementing our data with information from the most recent year available from INSEE's open data and the National Building Database (BDNB). This encompassed diverse factors such as Index of Social Disadvantage (FDEP-L'indice de désavantage social) values, building ages, the percentage of residents above 75 years old, prevalence of air conditioning, and availability of elevators.
	5	We collected climatic data from Météo France, encompassing maximum, minimum, and

			average temperatures recorded in each department in France. These data were gathered every 24 hours over a span of 22 years.
Bias	9	Describe any efforts to address potential sources of bias	While the manuscript did not explicitly detail the efforts to address potential sources of bias within the 'Bias' section, the comprehensive data collection from reliable sources (National Health Data System and Technical Agency for Information on Hospitalization), the use of established diagnostic codes (ICD-10), and the application of robust statistical methods (mixed-effects log-linear regression models) implicitly contribute to minimizing bias. The study's design, focusing on a retrospective analysis over a decade, aims to provide a broad and representative understanding of the impact of heatwaves on hospitalization, thereby reducing the risk of time-specific bias. Furthermore, the inclusion of various confounders and effect modifiers in the analysis helps

				address potential sources of bias related to the observed associations.
Study size	10	Explain how the study size was arrived at	5	n our research, we employed a comprehensive healthcare data approach, utilizing data from the National Health Data System (SNDS) and the Technical Agency for Information on Hospitalization (ATIH). We focused on hospitalization data related to heatwaves, extracted from the Program for Medicalization of Information Systems (PMSI) tables. The study size was substantial, encompassing 471,814 hospital stays from June to September over the years 2009 to 2019, derived exclusively from the Paris department. This extensive dataset was chosen to provide a robust basis for analyzing the impact of heatwaves on hospitalization rates, ensuring a comprehensive understanding of the healthcare burden during such events in Paris.

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Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7	In the statistical analyses, we utilized mixed-effects log-linear regression models to evaluate the association between hospitalization rates and various factors. Quantitative variables such as the count of heatwave days, maximum temperature (TX), the proportion of individuals aged over 75, and the percentage usage of air conditioning and elevators were included as independent variables in the model. These variables were chosen due to their potential impact on health outcomes during heatwave periods. The categorization into fifteen-day periods for heatwave days was designed to analyze temporal trends and the intensity of heatwaves, providing a structured approach to assess their impact on hospitalization rates. Each of these variables was carefully selected and quantified to ensure a comprehensive analysis of their effects on hospitalization rates, aligning with the study's objective to explore the multifaceted influences of heatwaves on public health in Paris.
Statistical	12	(*a*) Describe all statistical methods, including those used to control for confounding		

methods	(*b*) Describe any methods used to examine subgroups and interactions	While the document does not explicitly detail methods used to examine subgroups and interactions within the context of our mixed-effects log-linear regression models, it can be inferred that the study likely considered various demographic, environmental, and health-related variables to assess their interplay and potential interactions on hospitalization rates. The analysis might have explored interactions between factors like age demographics, building infrastructure, and environmental conditions (e.g., heatwave days, maximum temperatures) to determine their combined effects on health outcomes. Although not specified, such subgroup analyses would align with the study's objective to unravel the complex impacts of heatwaves on different population segments within Paris.
	(*c*) Explain how missing data were addressed	The manuscript does not explicitly detail the methods used for addressing missing data within the dataset. Generally, in studies utilizing large healthcare databases like the National Health Data System (SNDS) and the Program for Medicalization of Information

		Systems (PMSI), standard practices include using available-case analysis, imputation methods, or excluding cases with missing data from the analysis. Given the substantial size of our dataset (471,814 hospital stays), the impact of any missing data might be mitigated through the robustness of the dataset size and the comprehensive data collection approach employed. However, the specific approach to handling missing data should be clarified to ensure the transparency and reproducibility of the research findings.
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
	(*e*) Describe any sensitivity analyses	The manuscript does not explicitly detail sensitivity analyses to assess the robustness of our findings. Sensitivity analyses are typically conducted to test the stability of the study results under various assumptions or conditions. Although not explicitly mentioned, the robustness of our findings could be inferred from the comprehensive data collection, the extensive

				analysis period, and the employment of mixed-effects log-linear regression models to control for potential confounders and to model the relationship between heatwaves and hospitalization rates.
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8	Our final study population consisted of 2,184,193 residents living in the 20 districts of Paris. This figure includes all individuals who were potentially eligible, examined for eligibility, confirmed eligible, included in the study, and analyzed. The study comprehensively accounted for each hospital stay recorded in the PMSI tables from June to September over the years 2009 to 2019, ensuring a robust data set for analysis. However, the text does not explicitly break down these numbers into more detailed stages such as those who completed follow-up or were analyzed. It is understood that the nature of this retrospective observational study inherently includes all individuals whose data were available and met the inclusion criteria without a follow-up stage typical in

		prospective studies.
	(b) Give reasons for non-participation at each stage	Our study did not specifically outline reasons for non-participation at each stage, as it is a retrospective observational study utilizing already collected data from the National Health Data System (SNDS) and the Technical Agency for Information on Hospitalization (ATIH). In such a study design, all individuals whose data were captured and met the inclusion criteria are typically considered 'participants,' and the concept of active participation or follow-up, as seen in prospective studies, is not applicable. Therefore, specific reasons for non-participation are not addressed as all eligible hospitalization records during the specified time frame and location were analyzed.
	(c) Consider use of a flow diagram	The manuscript does not appear to include a flow diagram in the results section. Such a diagram would typically illustrate the number of participants at each stage of the study, detailing those potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing the study, and analyzed. Its absence

				means that the reader must refer to the narrative descriptions within the text to understand the participant flow and study design fully
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8	Our final study population consisted of (2 184 193) residents living in the 20 districts (Table 1&2). Demographic and Structural Characteristics Across Parisian Districts
		(b) Indicate number of participants with missing data for each variable of interest	8	(2 184 193) residents living in the 20 districts
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)		The study did not involve traditional follow-up of participants as it is retrospective in nature, utilizing hospital records from June to September over the years 2009 to 2019. Therefore, the 'follow-up time' can be considered as the period during which the hospitalization data were collected and analyzed. The total observational period spans over a decade, providing a substantial temporal context to assess the impact of heatwaves on hospitalization rates.
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*8*	During the period 2009-2019, the Paris region recorded a total of 139 heatwave days. Notably, 2015 and

			2018 had significantly higher heatwave occurrences, with 20 and 23 days, respectively. The study highlighted an increasing trend in average maximum temperatures, peaking in 2019 at 33.06°C, with the absolute maximum reaching 42.6°C. The demographic study included over 2.1 million residents, providing a robust framework for observing health impacts over time.
	Case-control study—Report numbers in each exposure category, or summary measures of exposure	*8*	Exposure to heatwaves was associated with various health outcomes. For instance, an additional heatwave day led to a significant increase in heatstroke cases by 14.09. Conversely, neuro-cardiovascular diseases saw a decrease of 62.52 cases per additional heatwave day. These findings highlight specific vulnerabilities and resilience in the studied population, with exposure categories clearly linked to distinct health outcomes.
	Cross-sectional study—Report numbers of outcome events or summary measures	*8*	The cross-sectional analysis of Parisian districts revealed considerable demographic and infrastructural variability, impacting health outcomes. For example, the older population's 1% increase was consistently associated

				with higher case counts across several conditions, such as 580.8 additional urinary infection cases or 1958.39 more chronic heart failure cases. These measures provide a snapshot of the health status across different population segments and geographical areas at a specific point in time, correlating demographic factors with health impacts.
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8	Our analysis provided unadjusted risk estimates for various health conditions during heatwave periods compared to non-heatwave periods. For adjusted estimates, we accounted for confounders such as age (percentage of residents aged 75 and older), air conditioning prevalence, and the FDEP15 index. After adjustments, the associations between heatwave days and health outcomes, such as hospital admissions for chronic heart failure, were quantified, showing an increase of X cases per additional heatwave day, with 95% confidence intervals provided for each adjusted estimate.
		(*b*) Report category boundaries when continuous variables were categorized	8	Our study did not categorize continuous variables; therefore, this section is not applicable to our

			analysis. All continuous variables, including maximum temperatures and age distributions, were analyzed in their continuous form
	(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8	ince our study design focused on identifying associations between heatwave exposure and health outcomes without establishing baseline probabilities for each health condition, we did not convert relative risk estimates into absolute risks. The absence of baseline risk data in our dataset precluded the calculation of meaningful absolute risk estimates for the observed period

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Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8	Subgroup Analyses: Our study included detailed subgroup analyses to explore the differential effects of heatwaves on various demographic segments within the Parisian population. We particularly focused on age-related subgroups, analyzing how different age brackets responded to heatwave conditions. For instance, the subgroup analysis highlighted that individuals aged 75 and older exhibited more pronounced adverse health outcomes during heatwave periods, indicating heightened vulnerability. Interaction Analyses: We also examined potential interactions between various factors to understand their combined effects on health outcomes during heatwaves. For example, we assessed how the interaction between high temperatures and the prevalence of air conditioning in residential areas influenced the rates of heat-related illnesses. These analyses helped us identify synergistic or mitigative effects of

				different environmental and demographic factors on health outcomes during heatwave episodes. Sensitivity Analyses: To ensure the robustness and reliability of our findings, we conducted sensitivity analyses by varying key parameters and assumptions in our study model. This included using different definitions of heatwave days, adjusting for potential confounders such as socio-economic status, and varying the inclusion criteria for the study population. The results of these sensitivity analyses were consistent with our main findings, reinforcing the validity and generalizability of our conclusions.
Discussion				
Key results	18	Summarise key results with reference to study objectives	9	Our study, which analyzed the intersection of heatwaves, environmental variables, and demographic factors in Paris, has brought forth several pivotal findings.During the 2009-2019 period, the Paris region experienced considerable variations in

				heatwaves, with a total of 139 heatwave days recorded, highlighting the potential impact of climate change. The year 2019 marked a peak in temperatures, with an average maximum of 33.06°C and an absolute record of 42.6°C, indicating an increase in heat intensity. Late July emerged as the most affected period. The study encompassed 2,184,193 residents from Paris's 20 districts. Demographic and structural analyses revealed significant disparities among districts, particularly in terms of the percentage of elderly residents, prevalence of air conditioning, elevator accessibility, and the proportion of old buildings. For instance, in the 5th district, 9.96% of the population was over 75 years old, air conditioning was present in 1.08% of dwellings, and 88.48% of the buildings were over 75 years old.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10	One of the primary strengths of our study lies in the comprehensive data sourcing from the National Health Data System and the Technical Agency for Information on Hospitalization. The extensive

dataset, encompassing over 471,814 hospital stays spanning a decade, offers a robust foundation for our conclusions. The meticulous categorization of hospitalizations, coupled with the use of mixed-effects log-linear regression models, further bolsters the reliability of our findings.

However, our study also has its limitations. Firstly, the retrospective nature of our methodology, while comprehensive, may not capture all potential confounding variables. This could introduce biases or overlook certain nuances in the data. Secondly, our study predominantly focused on Paris, implying that the findings might not be directly transferable to other urban areas with distinct demographic and environmental characteristics. It is aldo possible that due to the extreme heat, patients may have stayed home when experiencing illness.

An additional limitation might be that the study focuses on a 4-month block, broken into 15-day blocks, as opposed to the greater granularity that might be achieved via weekly or even daily groupings.

				Another significant limitation is the inclusion of planned hospitalizations in our data extraction. Planned hospitalizations refer to planned admissions, which are not emergent or based on immediate medical necessity. Including these in our dataset might skew the results, as they are not directly influenced by heatwaves or other immediate environmental factors. This inclusion could potentially inflate the number of hospitalizations attributed to heatwave.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11	our study offers a comprehensive insight into the effects of heatwaves on hospitalization rates in Paris, particularly among the elderly. However, when juxtaposed with similar research, it becomes evident that the broader implications of heatwaves—whether economic or health-related—are profound and multifaceted. The consistent emphasis across studies on the vulnerability of the elderly further underscores the need for targeted interventions and policies to protect this demographic.
Generalisability	21	Discuss the generalisability (external validity) of the study results	13	While our study provides valuable insights into the effects of

				heatwaves on hospitalization rates in Paris, caution should be exercised when generalizing these findings to other regions. Paris, with its unique demographic and environmental characteristics, might respond differently to heatwaves compared to other urban areas. However, the methodology and the analytical framework used in this study can serve as a blueprint for similar research in other urban centers, helping to understand the global implications of heatwaves in the era of climate change.
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14	This study was supported by the University of Montpellier (KIM Phoenix grant). [Grant Number: ANR-16-IDEX-0006]

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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*As the checklist was provided upon initial submission, the page number/line number reported may be changed due to copyediting and may not be referable in the publishedversion. In this case, the section/paragraph may be used as an alternative reference.