

Short-Term Impacts of Elevated Temperatures on Maternal and Child Health in Primary Care Visits: Insights from The Special Region of Yogyakarta

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Abstract. Maternal and child health is especially vulnerable to the impacts of climate change. In Indonesia, the Badan Meteorologi, Klimatologi, dan Geofisika (BMKG; Meteorological, Climatology, and Geophysical Agency) has reported a notable temperature increase, with an average increase of 0.8 °C compared with the 1991–2020 baseline. Although the relevant literature is expanding, empirical evidence from tropical regions—characterized by persistently high heat and humidity—remains scarce. This study intends to assess the existing evidence on the impact of elevated temperatures on maternal and child health in the Special Region of Yogyakarta, and to examine potential policy implications for fostering adaptations in health systems and preparedness for climate-related risks. Daily temperature data for 2021 were obtained from BMKG, while patient visit records to primary and referral healthcare facilities—specifically maternity and pediatric clinics—were sourced from the Social Security Agency for Health (BPJS) data sample. Analysis included data visualization, correlation analysis, and Poisson regression modeling. The results revealed a short-term association between elevated temperatures and increased daily maternal–child patient visits. However, data derived from Sundays and public holidays may inaccurately reflect this relationship, because many primary healthcare providers are not operational on these days. Nevertheless, these observations are important for assessing the overall weekly impact of elevated temperatures on patient visits. In conclusion, every 1 °C increase in average weekly temperature is associated with an estimated 15.5% increase in maternal–child patient visits to primary healthcare facilities (95% CI: 2.8–29.7%). This association may reflect underlying biological mechanisms such as impaired placental function and reduced uterine blood flow. The study highlights the importance of developing climate-responsive health

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early warning systems, adjusting service delivery in primary care settings during periods of high temperature, and enhancing health education for pregnant women and caregivers to mitigate temperature-related health risks.

1 Introduction

In recent years, climate change has posed significant and urgent challenges to global health. The most vulnerable populations to the adverse impacts of climate change are pregnant women and children. Their physiological and immunological characteristics render them especially susceptible to environmental stressors such as extreme temperatures [1,2]. The World Health Organization (WHO) has identified pregnant women, newborns, and children as among the most vulnerable populations to climate-related health risks. It notes that exposure to elevated ambient temperatures is associated with a wide range of adverse maternal and perinatal outcomes, including gestational diabetes mellitus, hypertensive disorders of pregnancy, preterm birth, low birth weight, and stillbirth. Furthermore, the WHO emphasizes the potential negative impacts of climate-related stressors on maternal mental health and contribution to intergenerational trauma through increased levels of stress, anxiety, and depression during the perinatal period [3].

Previous studies demonstrate that elevated ambient temperatures are associated with heightened risks of preterm birth, low birth weight, dehydration, heat-related illnesses, and respiratory infections among infants and young children [4]. Evidence from a recent systematic review and meta-analysis highlights significant health risks associated with elevated ambient temperatures. Using data from 198 studies conducted across 66 countries, the review emphasized that an increase of 1°C in heat exposure was associated with an increase of 4% in the odds of preterm birth (OR = 1.04; 95% CI: 1.03–1.06), while exposure to periods of sustained high temperatures increased the odds by 26% (OR = 1.26; 95% CI: 1.08–1.47). Exposure to elevated temperatures was also linked to increased risks of stillbirth (OR = 1.13), congenital anomalies (OR = 1.48), gestational diabetes mellitus (OR = 1.28), and obstetric complications during periods of high heat (OR = 1.25). Patterns of vulnerability varied according to outcome, thus underscoring the complexity of temperature–health interactions and the importance of identifying critical windows of exposure [5].

The increased vulnerability of pregnant women to elevated ambient temperatures is primarily due to physiological adaptations during gestation, including increased cardiovascular demands and decreased thermoregulatory efficiency. Although core thermoregulatory mechanisms are generally preserved throughout pregnancy, exposure to high temperatures may overwhelm these compensatory capacities, resulting in decreased uteroplacental blood flow, dehydration, and pro-inflammatory responses—factors that may contribute to adverse obstetric outcomes such as preterm birth [7]. Similarly, infants and young children are susceptible due to their relatively high surface-area-to-mass ratio, elevated metabolic heat production, and immature sweating mechanisms. These characteristics impair their thermoregulatory capacity, thus placing them at increased risk of heat-related morbidity [7].

During pregnancy, women experience various physiological adaptations, including increased cardiovascular demands and a diminished capacity for thermoregulation. However, various factors may enhance women’s sensitivity to heat exposure, potentially exacerbating maternal health concerns [4]. In the same vein, thermoregulation in infants and young children is underdeveloped, which may lead to severe health consequences when they are exposed to high temperatures. Limited access to healthcare and socioeconomic disparities in low- and middle-income countries (LMICs), which compound the vulnerability of maternal and child populations, further heighten these risks [5].

Indonesia is also experiencing significant climate change. The Meteorological, Climatology, and Geophysical Agency (Badan Meteorologi, Klimatologi, dan Geofisika [BMKG]) has documented an average increase of 0.8°C in temperature compared with the 1991–2020 baseline [6]. This warming trend poses profound implications for public health, particularly in urban and semi-urban areas, where heat exposure is intensified by population density and limited green infrastructure [8]. Despite the expanding body that reports global evidence of the association between climate change to health outcomes, empirical research that addresses the specific impacts of elevated temperature on maternal and child health in tropical regions such as Indonesia remains limited. Tropical settings—characterized by distinct patterns of climatic exposure and population vulnerability, are underrepresented in the literature compared with temperate regions. The absence of context-specific evidence constrains the ability of policymakers in Indonesia and similar countries to formulate effective climate-health adaptation strategies. Therefore, addressing this evidence gap is essential for ensuring that maternal and child health programs remain responsive to local environmental and sociodemographic realities.

The Special Region of Yogyakarta presents a compelling context for investigating this relationship due to its rapidly urbanizing environment, high population density, and robust data on healthcare utilization through the national health insurance system. Primary healthcare centers in this region are pivotal in delivering essential maternal and child health services, thus, rendering the region an ideal setting for understanding the real-world health impacts of short-term temperature variability.

This study aims to assess the short-term effects of elevated temperatures on maternal and child health by analyzing patterns in daily patient visits at primary healthcare facilities in Yogyakarta. In addition to quantifying these associations, the study intends to inform policy development on health system adaptations, such as strengthening health early warning mechanisms, improving service readiness during periods of elevated heat, and integrating climate risk management into maternal and child healthcare planning. Daily temperature data from the BMKG and healthcare visit records from Social Security Agency for Health were integrated and analyzed using the data visualization, Poisson regression, and Pearson correlation methods. This study explores the potential influence of ambient temperature fluctuations on healthcare-seeking behavior and health burden among vulnerable populations. It also examines the role of weekly patterns, including Sundays and public holidays, in modulating access to and demand for healthcare services.

In Indonesia, indicators of maternal and child health continue to reflect persistent public health challenges. In 2022, the national prevalence of stunting reached 21.6%, while the Special Region of Yogyakarta reported a prevalence of 16.4%, which exceeded the WHO's recommended threshold of 14% [9]. The prevalence of anemia among pregnant women also remains high, increasing from 37.1% in 2013 to 48.9% in 2018 [10]. Although coverages of antenatal care (K4) and neonatal visits reached 88.7% and 84.4% in 2023, respectively, service utilization rates failed to translate into improved health outcomes [11,12]. These persistent health burdens indicate that the maternal and child population in Indonesia remains highly vulnerable and may be disproportionately impacted by additional climate-related stressors such as elevated ambient temperatures. This scenario underscores the urgency of integrating climate resilience into maternal and child health strategies.

Elucidating the short-term effects of elevated temperatures on maternal and child health is crucial for the formulation of local adaptation strategies in the health sector, especially in anticipation of future climate changes. This study contributes to the emerging discourse on climate-sensitive health systems in LMICs. Furthermore, it emphasizes the urgent need to integrate climate resilience into primary care planning and maternal–child health policies. In Indonesia, however, this integration remains limited. Currently, clinical guidelines or health early warning systems that specifically address risks faced by mothers

and children during periods of elevated heat or other climate-related events have not been established. This gap in policy underscores the pressing need to implement climate-adaptive measures in Indonesia's health system to better protect vulnerable populations.

2 Methods

This study was conducted in the Special Region of Yogyakarta in Indonesia. This region was classified as Am under the Köppen–Geiger climate classification system, which denotes a tropical monsoon climate characterized by consistently warm temperatures, high levels of humidity, and distinct wet and dry seasons throughout the year.

We used the third edition of the BPJS Health sample dataset, which was released in December 2021, and contained anonymized health records. The dataset provides general and contextual health information, with a particular focus on maternal and child health. For analysis, we filtered the data to include records from Yogyakarta Province (notated as FKP05 == 34) and patient visits to maternal and child health clinics (FKP11 == 3). Furthermore, we included patient visits referred explicitly for maternal and child healthcare services (denoted as FKL09 == 16). To align with the temporal and spatial scopes of the health dataset, the researchers obtained daily temperature data from January to December 2021, from the BMKG. The dataset contained no duplicate entries, and no imputation or treatment of missing values was performed.

The relationship between temperature and maternal–child health visits to primary healthcare facilities was investigated by analyzing the average daily temperatures per week and per month. Line and box plots were also employed to visualize data across multiple temporal scales (i.e., daily and weekly)—enabling the identification of patterns and trends, including seasonal variations that may differ according to the level of temporal aggregation.

We then computed Pearson correlation coefficients to measure the strength and direction of the association between temperature and number of maternal–child health visits. A Poisson regression model was employed to estimate expected changes in patient visits associated with each 1 °C increase in temperature. For ease of interpretation, we assumed a linear relationship between temperature and number of maternal–child health visits. This assumption may represent a limitation of the study, as fails to account for potential nonlinear effects. Given that this study aimed to explore the general association between elevated temperatures and maternal–child health visits to healthcare facilities, we accounted only for the day of the week and set public holidays as covariates to reflect operational schedules in healthcare. The exclusion of other potential confounding variables represents another limitation of this study.

This study exclusively relied on secondary data obtained from the BMKG and the BPJS Health sample dataset. As no direct interaction with human participants was conducted, ethical approval was not required. BPJS Health granted the author permission to use anonymized individual health insurance data for research purposes.

3 Results And Discussion

This study examined the short-term association between ambient temperature and number of maternal–child patient visits to primary and referral healthcare services in the Special Region of Yogyakarta, Indonesia. It analyzed daily records of temperature and patient visits across multiple lag periods, including up to 14 days for daily data and 8 weeks for weekly aggregates.

The number of patient visits to healthcare services was higher on weekdays (Monday to Saturday) compared with that on Sundays and public holidays, particularly for primary care services. Average daily visits were consistently highest on Mondays, while Sundays recorded the lowest number of visits, thus reflecting the operational hours of primary care facilities (Fig. 1C and D). Referral care visits were fewer and more sporadic across the days of the week and did not exhibit a clear day-of-week pattern.

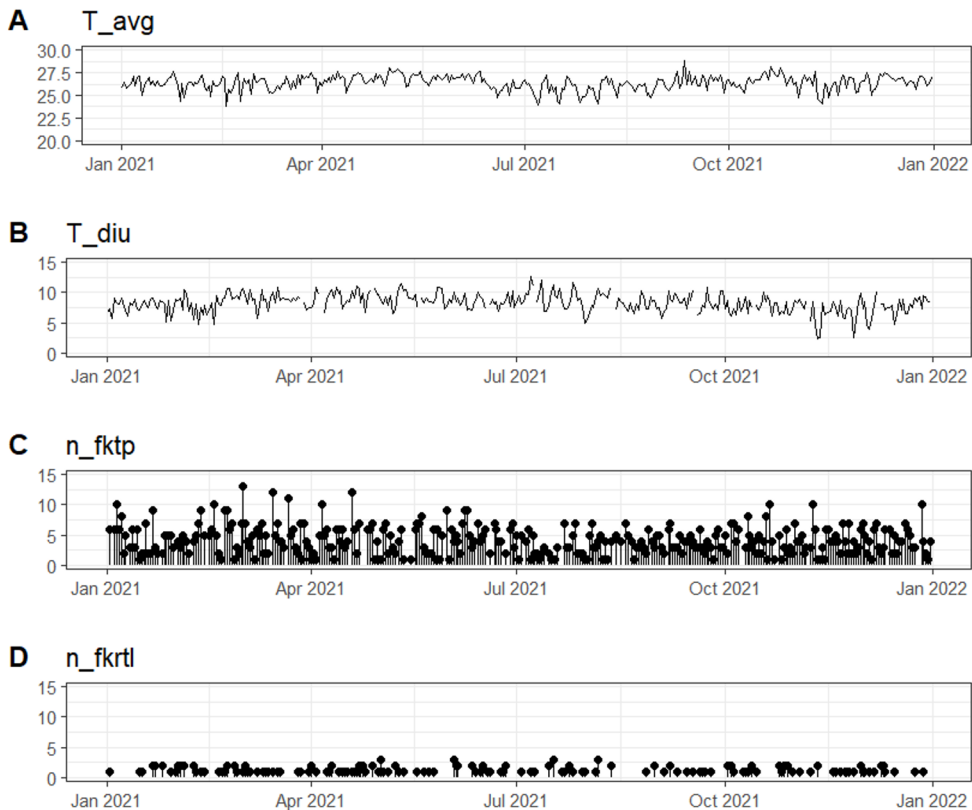


Fig. 1. Datasets on average daily temperature (T_{avg}), diurnal temperature variation ($T_{diu} = T_{max} - T_{min}$), primary care MCH visits (n_{fktp}), and hospital visits (n_{fkrtl})

The study period in 2021 recorded average daily temperatures (T_{avg}) that ranged from approximately 23°C to up to 30°C (Fig. 1A). Although trends in temperatures remained relatively stable throughout the year, a gradual increase was observed from January to May, with a slight peak in September followed by stabilization toward the end of the year. Diurnal temperature variation (T_{diu}) was defined as the difference between daily maximum and minimum temperatures and ranged from 0°C to 15°C; during the majority of the days, they decreased between 5 °C and 12°C (Fig. 1B). These fluctuations were seemingly more prominent during the transitional months between the rainy and dry seasons.

Dynamic patterns during the year were evident in daily visits to maternal–child health services. These visits occurred within primary care facilities (n_{fktp} ; Fig. 1C). Typically, the visit volume was higher during weekdays (i.e., Monday to Saturday). Service availability patterns in the primary case led to a sharp decrease in volume during public holidays and Sundays. In contrast, daily visits to referral hospitals (n_{fkrtl}) were sparse and inconsistent

(Fig. 1D), with low or no visits recorded for the majority of days. In general, the count of visits for primary care was consistently higher than that for referral care, which indicates that the majority of maternal and child health needs were addressed at the level of primary care.

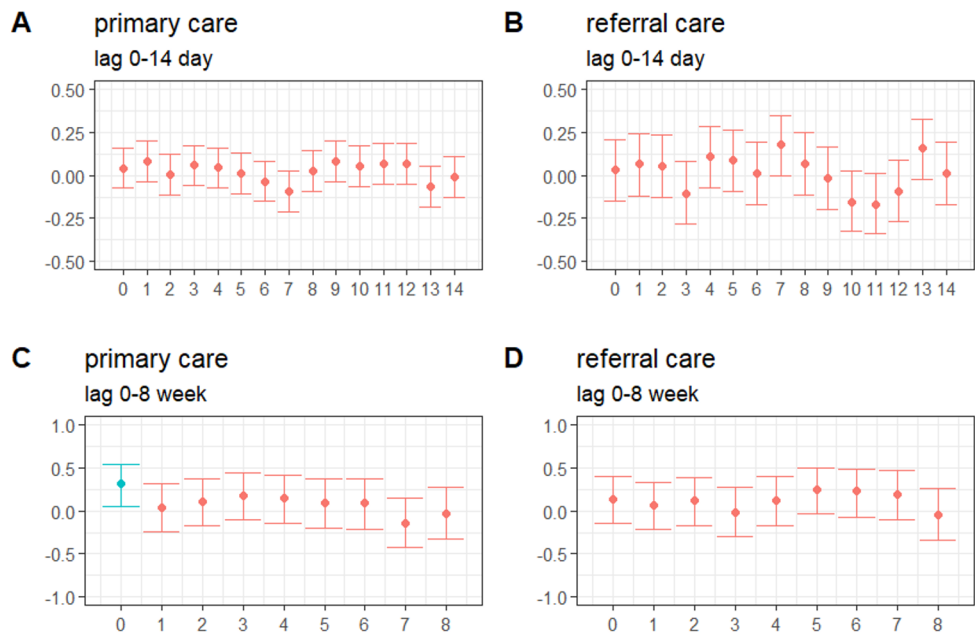


Fig. 2. Pearson correlation between daily temperature and numbers of daily and weekly visits.

Correlation analysis revealed notable short-term associations between average temperature (T_{avg}) and maternal–child health visits (Fig. 2). At the daily level (lags 0–14 days), increases in temperature were positively correlated with visits to primary care facilities, particularly on lag days 1–3, in which the correlation coefficients reached their peak (Fig. 2A). The strength of the association gradually decreased in subsequent days and approached null values after day 7. For referral care visits, however, the study found no consistent or statistically meaningful correlation at any daily lag (Fig. 2B).

When examined at the weekly scale (lags 0–8 weeks), the association between temperature and primary care visits remained evident (Fig. 2C). The most pronounced and statistically significant correlation was observed during the same week as the temperature change (lag week 0), with a coefficient nearing 0.5. This finding indicated that fluctuations in ambient heat during a given week were promptly reflected in healthcare-seeking behavior at the primary care level. After the first week, the strength of the association declined and lost statistical significance. In contrast, the weekly correlation with referral care visits (Fig. 2D) remained low and nonsignificant across the observed lag periods.

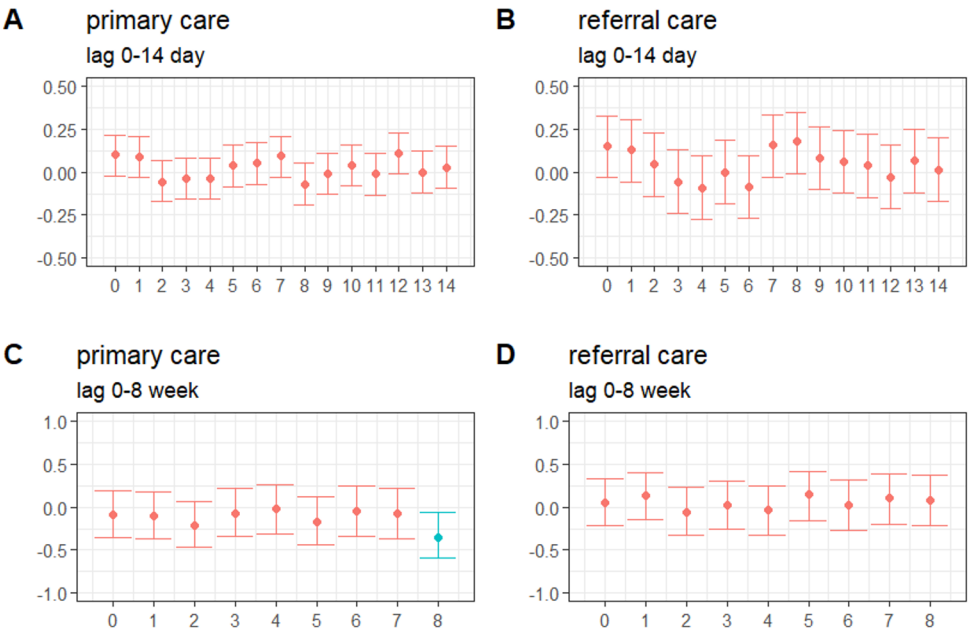


Fig 3. Pearson correlation between diurnal temperature variation and numbers of daily and weekly visits.

Based on the results of the Pearson correlation, analysis was conducted to determine the association between daily temperature variation (T_{diu})—specifically, the difference between maximum and minimum daily temperatures—and number of healthcare visits to primary care facilities (FKTP) and referral care facilities (FKRTL) across two temporal scales: daily lags (lags 0–14 days) and weekly lags (lags 0–8 weeks). For the daily lag analysis (lag 0–14 days), the study found no statistically significant correlation between T_{diu} and number of daily visits to FKTP (Fig. 3A) or FKRTL (Fig. 3B). The correlation coefficients remained close to zero across all lag periods, and confidence intervals encompassed the null value. These findings implied that short-term fluctuations in daily temperature variation did not significantly influence healthcare utilization rates in the subsequent two weeks.

Similar patterns were observed in the weekly lag analysis (lags 0–8 weeks). The majority of correlation coefficients between T_{diu} and weekly visit counts were weak and statistically nonsignificant. However, the study identified a notable exception at lag week 8 for FKTP visits, observing a statistically significant negative correlation. This finding indicates that larger temperature variations eight weeks prior may be associated with decreases in primary care utilization, thus potentially emphasizing delayed or indirect health impacts, behavioral adaptation, or changes in health-seeking behavior over time. No significant correlations were found for visits to FKRTL across all weekly lags.

Table 1. Weekly maternal–child patient visit model

Model	Estimate	LL	UL	p-value	
n_fktp ~ Tavg	1.155	1.028	1.297	0.016	*
n_fkrtl ~ Tavg	1.174	0.859	1.604	0.314	
n_fktp ~ Tdiu	0.977	0.907	1.053	0.547	
n_fkrtl ~ Tdiu	1.037	0.878	1.224	0.671	

The result of log-linear regression analysis exhibited a statistically significant association between weekly average temperature (T_{avg}) and number of visits to primary healthcare facilities (FKTP visits) per week. Specifically, an increase of 1 °C in T_{avg} was associated with an increase of 15.5% in primary healthcare visits (estimation = 1.155; 95% CI: 1.028–1.297; $p = 0.016$), which indicates a potential increase in primary healthcare utilization related to temperature.

In contrast, the association between T_{avg} and weekly visits to secondary referral healthcare facilities (FKRTL) was statistically nonsignificant (estimation = 1.174; 95% CI: 0.859–1.604; $p = 0.314$), which indicates that average ambient temperature did not substantially influence secondary healthcare utilization rates during the study period. In addition, diurnal temperature variations (T_{diu}) were not significantly associated with visits to primary ($p = 0.547$) or secondary ($p = 0.671$) health facilities. These findings demonstrate that temperature fluctuations, as measured by T_{diu} , exert no measurable short-term effects on healthcare-seeking behavior.

This study provides robust empirical evidence that short-term elevations in average ambient temperature are significantly associated with increased utilization rates of maternal–child health services in primary care facilities in Yogyakarta. Specifically, an increase of 1 °C in weekly temperature was associated with an increase of 15.5% in primary healthcare visits, thus reinforcing the existence of the association between temperature and health within this vulnerable population. This relationship is biologically plausible. Scholars have demonstrated that heat exposure can impair thermoregulation and increase cardiovascular strain among pregnant women, potentially leading to symptoms such as dehydration, fatigue, and premature uterine activity, which necessitate clinical intervention [13]. Heat exposure also exerts adverse impacts on pregnancy and birth outcomes such as preterm birth, low birth weight, stillbirth, gestational diabetes mellitus, and hypertension during pregnancy [5,15]. In pediatric populations, elevated ambient temperatures have been associated with increased incidences of febrile illnesses, diarrheal diseases, and respiratory infections due to immature physiological systems and disproportionately high surface-area-to-mass ratios [13].

The study observed no consistent association between variation in diurnal temperature and healthcare utilization. This finding indicates that short-term demands for health services are more strongly influenced by sustained thermal exposure than by intraday fluctuations in temperature. These results are consistent with those of prior research reporting that the mean temperature serves as a more stable and predictive metric in assessing the health effects of ambient heat than diurnal temperature range. A previous study reported that elevated mean temperatures were constantly associated with increased maternal–neonatal morbidity rates, whereas associations with temperature variability were heterogeneous and less reliable [14].

The temporal distribution of associations further supports this interpretation. Increases in primary care visits peaked between one and three days after an increase in ambient temperature and attenuated thereafter, thus indicating a relatively immediate behavioral or physiological response. The absence of statistically significant associations with visits to FKRTL implies that the majority of heat-related cases were effectively managed within the primary care system, which functions as the principal point of entry for maternal–child health services under Indonesia’s national health insurance framework (BPJS). These findings

highlight the critical role of primary healthcare infrastructure in responding to climate-sensitive health demands, particularly in LMIC settings with limited referral capacity.

The findings align with global evidence on the impact of climate on child health outcomes. A recent multi-country analysis demonstrated that even minor increases in ambient temperature were associated with elevated rates of child morbidity across 14 LMICs, particularly in tropical and subtropical climates. These international parallels reinforce the external validity of the present study and imply that the observed relationships are not unique to the Indonesian context [5].

The current findings emphasized the sensitivity of maternal–child healthcare utilization to short-term increases in ambient temperature in tropical urban environments. With the acceleration in global climate change, health systems in LMIC must proactively incorporate environmental surveillance and temperature-responsive health service planning to sustain their service delivery and protect vulnerable populations from climate-sensitive morbidity.

This study has its limitations. First, the use of secondary data from BPJS may lead to underrepresentation of certain demographic groups, thus affecting the generalizability of the findings. Second, its sole focus on temperature may overlook other important factors, such as humidity and rainfall, which can impact maternal–child health. Third, variations in healthcare utilization may also be influenced by non-climatic factors, such as public holidays and shifting service hours, which lacked adequate examination.

Despite these limitations, the findings pose significant implications for health policy. They underscore the importance of developing primary healthcare systems that can adapt to the impacts of climate change to prevent climate-related diseases. A key recommendation of the study is the integration of climate data, such as temperature, humidity, and rainfall from the BMKG into health monitoring systems to improve contingency plans for climate-related health risks. Health education programs should also address heat exposure by educating pregnant women about associated risks and preventive measures against heatstroke. Furthermore, strengthening the capacity of primary healthcare workers to manage patient surges during periods of extreme heat is essential for protecting maternal–child health.

4 Conclusion

This study provides empirical evidence that short-term increases in average ambient temperature are significantly associated with higher utilization rates of maternal–child health services at the primary care level in Yogyakarta. An increase of 1 °C in weekly average temperature corresponds to an increase of 15.5% in visits, thus highlighting the acute sensitivity of maternal–child health to heat exposure. While mean temperature pointed to a consistent relationship with service use, diurnal temperature variation did not, which underscores the importance of sustained thermal conditions in driving health-seeking behavior. The findings align with those reported in the global literature and affirm that primary care systems play a critical role in the management of climate-sensitive health outcomes, especially in resource-limited settings. With the intensification of climate change, integrating heat surveillance and adaptive health service planning into public health systems will be essential for protecting vulnerable populations, particularly mothers and children, from escalating environmental health risks.

Furthermore, the results underscore the need for practical strategies for strengthening primary care responses to climate-related health challenges. These strategies include the development of climate-based health early warning systems, adjustments in primary care capacity during periods of elevated temperature, and targeted health education for pregnant women and parents regarding heat-related risks. These measures are critical for safeguarding

maternal–child health in the face of increasing environmental threats driven by climate change.

References

1. World Health Organization. Climate Change and Health. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>. (2021).
2. Romanello, M. *et al.* The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *Lancet* **398**, 1619–1662 (2021).
3. World Health Organization. *Protecting Maternal, Newborn and Child Health from The Impacts of Climate Change: A Call for Action*. <https://www.who.int/publications-detail-redirect/9789240085350>. (WHO, 2023).
4. Bekkar, B. *et al.* Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. *JAMA Netw Open* **3**, e208242 (2020).
5. Lakhoo, D. *et al.* Impacts of heat exposure on pregnant women, fetuses and newborns: a systematic review and meta-analysis. Preprint at *Research Square* (2024). <https://doi.org/10.21203/rs.3.rs-4713847/v1>
6. Agency for Meteorology, Climatology, and Geophysics. KLIMA: Information and Publication Media of the Deputy for Climatology, BMKG, 7th Edition 2022 (In Indonesian). <https://iklim.bmkg.go.id/>. (BMKG, 2022).
7. Samuels, L. *et al.* Physiological mechanisms of the impact of heat during pregnancy and the clinical implications: review of the evidence from an expert group meeting. *Int. J. Biometeorol.* **66**, 1505–1513 (2022).
8. Van de Kamp, E. & Daanen, H. Narrative Review on Infants' Thermoregulatory Response to Heat. *Int. J. Environ. Res. Public Health* **22**, 25 (2025).
9. Ministry of Health of the Republic of Indonesia. (2022). *Indonesia Nutritional Status Survey (SSGI) 2022*. Jakarta: Ministry of Health.
10. Research and Development Agency for Health, Ministry of Health of the Republic of Indonesia. National Report on Basic Health Research 2018 (In Indonesian). (Ministry of Health of the Republic of Indonesia, 2018).
11. Hartinah, A. *et al.* Care for perineal tears in vaginal delivery: An update for midwife. *Gac. Sanit.* **35**, S216–S220 (2021).
12. Ministry of Health of the Republic of Indonesia. Indonesia Health Profile 2023 (In Indonesian). (Ministry of Health of the Republic of Indonesia, 2024)
13. Zhang, Y., Yu, C. & Wang, L. Temperature exposure during pregnancy and birth outcomes: An updated systematic review of epidemiological evidence. *Environ. Pollut.* **225**, 700–712 (2017).
14. Filho, W. L. *et al.* Addressing the Urban Heat Islands Effect: A Cross-Country Assessment of the Role of Green Infrastructure. *Sustainability* **13**, 2769 (2021).
15. Lin, J. *et al.* Impact of ambient temperature on adverse pregnancy outcomes: a birth cohort study in Fuzhou, China. *Front Public Health* **11**, (2023).