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Report

Association Between Ambient Temperature and Community-Acquired Acute Kidney Injury in Japan: A Nationwide Claims and Meteorological Data Analysis

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BACKGROUND: Acute kidney injury (AKI) is associated with progression to chronic kidney disease, initiation of dialysis, and a decline in quality of life. Although rising temperatures have been linked to an increased risk of AKI, evidence regarding this association among outpatients in Japan remains limited. This study evaluated the association between community-acquired AKI (CA-AKI) and temperature using prefecture-level aggregated data. **METHODS:** We used Health Weather, a database integrating Japanese claims data with meteorological information. Among 4,868,549 individuals, we calculated the daily incidence of CA-AKI across 47 prefectures from 2018 to 2019. Associations were evaluated using the Cochran–Armitage trend test. **RESULTS:** CA-AKI incidence significantly increased as daily mean temperatures rose ($p = 0.003$). **CONCLUSIONS:** CA-AKI in Japan is significantly associated with higher temperatures. Preventive strategies should be tailored to the climatic characteristics of each geographic area.

Key words acute kidney injury, outpatients, temperature

INTRODUCTION

Acute kidney injury (AKI) is associated with progression to chronic kidney disease, initiation of dialysis, and a decline in quality of life.^{1,2)} Therefore, early detection and prevention of AKI represent critical clinical issues. Prerenal AKI accounts for the majority of community-acquired AKI (CA-AKI) cases.³⁾ Dehydration, a primary risk factor for prerenal AKI, is strongly influenced by environmental factors such as ambient temperature and humidity.

Previous studies have reported an increase in AKI incidence among emergency department patients during the summer, when temperatures are higher. In Japan, although the risk of emergency transport for genitourinary diseases has been reported to increase with rising temperatures,⁴⁾ the specific contribution of AKI within these conditions (e.g., AKI, urolithiasis, urethritis) and its detailed correlation with temperature have not been fully elucidated. Thus, the direct association between temperature and AKI incidence among outpatients in Japan remains unclear.

In this study, we evaluated the association between CA-AKI and ambient temperature using prefecture-level aggregated data from a large-scale database integrating Japanese administrative claims data with meteorological information.

METHODS

Data Sources and Study Design Data analysis was conducted using Health Weather, an aggregated dataset combining administrative claims data from JMDC Inc. with meteorological information provided by the Japan Weather Association. For meteorological data, daily mean ambient temperatures recorded at the capital city of each prefecture were used. Among 4,868,549 insured individuals enrolled in health insurance societies covered by the JMDC database between September 2017 and January 2020, we used data on the daily number of CA-AKI cases aggregated at the prefectural level from 1 January 2018 to 31 December 2019. The prefecture for each case was identified based on the location of the hospital where the patient received treatment. Annual population data for each prefecture were obtained from the Portal Site of Official Statistics of Japan (<https://www.e-stat.go.jp/>).

Definitions AKI events were identified from claims information using codes from the 10th edition of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). In this study, AKI was defined using ICD-10 codes N17, N19, and R34.⁵⁾ Renal anemia was excluded from the definition of AKI because it may include cases of chronic kidney disease. Among the identified AKI cases, those with

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a “suspected diagnosis” flag in the claims data were excluded to limit the analysis to confirmed diagnoses. CA-AKI was defined as cases in which the date of initiation of AKI treatment coincided with the date of hospital admission.

Statistical Analysis To account for substantial differences in population across Japanese regions, the incidence rate of CA-AKI per 1,000,000 person-years was calculated by dividing the number of CA-AKI cases by the population of each prefecture. The Cochran–Armitage trend test was used to evaluate whether there was a significant linear trend in CA-AKI incidence across different average temperature categories. The significance level was set at $p < 0.05$. Statistical analyses were performed using JMP® Pro 18.0 software (SAS Institute Inc., Cary, NC, USA).

RESULTS

Figure 1 shows the daily number of CA-AKI cases per 100 million people in relation to the daily mean temperature across all study regions. The Cochran–Armitage trend test revealed that the incidence of CA-AKI was significantly higher at higher daily mean temperatures ($p = 0.003$). The specific CA-AKI incidence rates for each prefecture are provided in Supplementary Table 1.

DISCUSSION

In this study, we demonstrated that the incidence of CA-AKI in Japan was significantly higher at higher daily mean temperatures (Fig. 1). This finding is consistent with previous studies reporting a positive correlation between AKI onset and temperature.^{6,7)} Supplementary Table 1 presents the population-adjusted incidence rates of CA-AKI in each prefecture as reference data underlying the analysis of the association between temperature and CA-AKI incidence. However, these prefecture-level data were not intended for detailed regional comparisons, and further investigations are warranted to clarify potential regional factors.

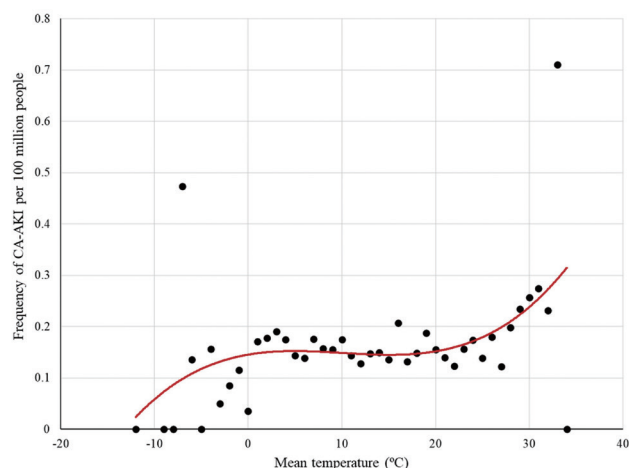


Fig. 1. Association between Ambient Temperature and Incidence of CA-AKI in Japan.

The scatter plot displays the daily incidence of CA-AKI per 100 million individuals in relation to the daily mean temperature (per 1°C). The red line represents a fitted regression curve (cubic function). CA-AKI: community-acquired acute kidney injury

This study has some limitations. First, because Health Weather provides aggregated data, individual patient background information could not be obtained. Additionally, because the association between temperature and CA-AKI incidence may vary according to patient characteristics, such as concomitant medications, comorbidities, sex, and age, further investigation is warranted. Second, the occurrence of AKI was identified by the disease name on the claims using ICD-10 codes. The data used in this study did not include laboratory data. Therefore, we were not able to identify the disease by laboratory values or by following fluctuations in these values. While previous research reported a low sensitivity (60%) but high specificity (86%) for AKI identification via ICD-10 codes,⁸⁾ this may have led to an underestimation of the true incidence. Third, the temperatures used in this study were those recorded at the prefectural capitals, which may differ from the actual temperatures to which individuals were exposed. This exposure misclassification could be due to uncontrolled factors such as microclimates, urban-rural differences, and indoor environmental conditions (e.g., air conditioning use). Fourth, because outpatient cases were defined as those in which the date of AKI treatment initiation coincided with the date of hospital admission, the dataset may include cases of hospital transfer or cases where AKI had already developed prior to admission, representing a potential misclassification of CA-AKI. Furthermore, mild cases of renal dysfunction not requiring hospitalization were excluded, potentially leading to an underestimation of the total number of AKI cases. Fifth, the JMDC Claims Database used in this study does not include data for individuals aged 75 years or older who have transitioned to the Advanced Elderly Medical Service System. Although older adults are generally considered to be at higher risk of dehydration, the association with temperature observed in this study population suggests that the impact of temperature is also relevant in relatively younger age groups.

In Japan, the incidence of CA-AKI increased significantly as ambient temperatures rose. These findings suggest the importance of regional-specific public health awareness and monitoring tailored to local climatic characteristics.

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Conflict of interest The Department of Pharmaceutical Packaging Technology endowed chair, to which Tetsumi Irie belong, has received donations from Kyoto Seisakusho Co., Ltd., Taisei Kako Co., Ltd., and Heartfelt Co., Ltd. All other authors declare no conflict of interest.

Ethics approval and consent to participate All methods were performed in accordance with the relevant guidelines and regulations. This study was approved by the Ethics Committee of the Department of Epidemiology and General Medicine, Graduate School of Life Sciences, Kumamoto University (Approval No. 2270). The requirement for informed consent was waived by the Ethics Committee because this study was a retrospective analysis of fully anonymized data.

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