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State-level weather pattern and utilization of skin cancer related procedures among Medicare beneficiaries.

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To the Editor:

Utilization of skin cancer-related procedures has been steadily rising in the last decade because of aging population and increased surveillance [1]. State-level utilization rates vary, which have been attributed to differences in population demographics and clinical practice. Few studies examined the impact of state-level weather pattern on utilization of skin cancer-related procedures. Warm sunny days encourage outdoor activities, which increase exposure to ultraviolet radiation, a major cause of skin cancers. Warmer states also attract older patients: nearly a quarter of older Americans live in sunny California, Texas, and Florida [2]. With climate-change-related rising temperatures and the prediction that by 2040, older Americans will account for more than 20% of the population [3], quantifying the potential impact of weather patterns on utilization of skin cancer-related procedures can assist in predicting demands for these services, especially in warmer states that will likely continue to see an influx of older patients.

Our study analyzes the relationship between weather parameters including temperature, number of clear days and ultraviolet index, and state-level utilization of skin cancer-related procedures based on 2017 Medicare physician payment data. Procedure utilization rate was calculated as the number of Mohs surgery, excision surgery, and destruction of malignant skin neoplasms per 100,000 Medicare beneficiaries. State-level temperature,

ultraviolet index, and number of clear days data were collected from National Oceanic and Atmospheric Administration, National Weather Service and Google Current Results, respectively. Data were visualized with MapChart and analyzed with univariate linear and non-linear polynomial regression models, followed by multivariate analyses with predictors of interest.

States in South and West regions have warmer temperatures and higher ultraviolet indices. Florida has both the highest average temperature 69.2°F and ultraviolet index 9.3. North Dakota has the lowest average temperature 37.5°F, whereas Washington has the lowest ultraviolet index 4.4 (**Figure 1A, Figure 2A**). Warmer temperatures are strongly correlated with higher ultraviolet index: Ultraviolet index increases by one unit for every 6.26°F rise in temperature ($P < 2^{-16}$). States with warmer temperatures ($P = 0.1$) and higher ultraviolet index ($P = 0.04$) are more likely to have higher procedure utilization rates. Procedure utilization rate increases by 2.8 for each 10°F increase in temperature (**Figure 1C**) and by 1.65 for each unit increase in ultraviolet index (**Figure 2C**). There is a positive but statistically non-significant trend between the annual number of clear days and procedure utilization rate.

Our results showed state-level correlation between higher procedure rate and elevated temperature and ultraviolet index, except for New England states. We considered the possibility of dermatologists' density being a confounding factor [4], but linear regression analysis showed no significant correlation. However, multiple other factors can influence skin cancer

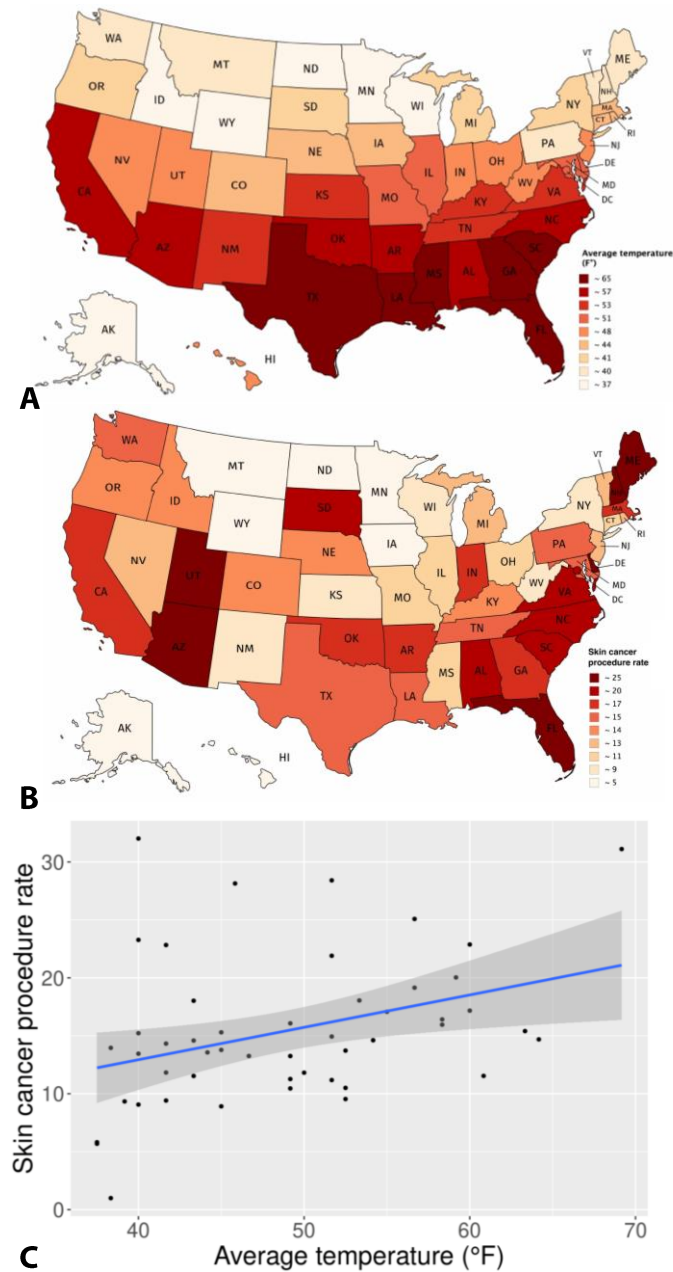


Figure 1. Correlation between average temperature and state-level skin cancer procedure utilization rate in the Medicare population. **A)** Map of average temperature in the United States. **B)** Map of skin cancer procedure rate in the United States. **C)** Scatterplot of average temperature versus skin cancer procedure rate and corresponding linear fit.

procedure rates for a particular state including local practice norms, trends of outdoor recreational activities, and travel patterns such as seasonal migration from colder to warmer states [5]. Our findings demonstrate that states with warmer temperatures and higher ultraviolet index are more likely to have a higher skin cancer procedure rate,

partly related to increased levels of outdoor activities and ultraviolet exposure, and partly related to the migration patterns of older Americans. From 2008 to 2019, nearly 5 million Americans age 65+ moved to the top 10 warmest states compared to just 1.5 million to the 10 coldest states [6]. Seven of the top 10 states with highest influx of retirees have

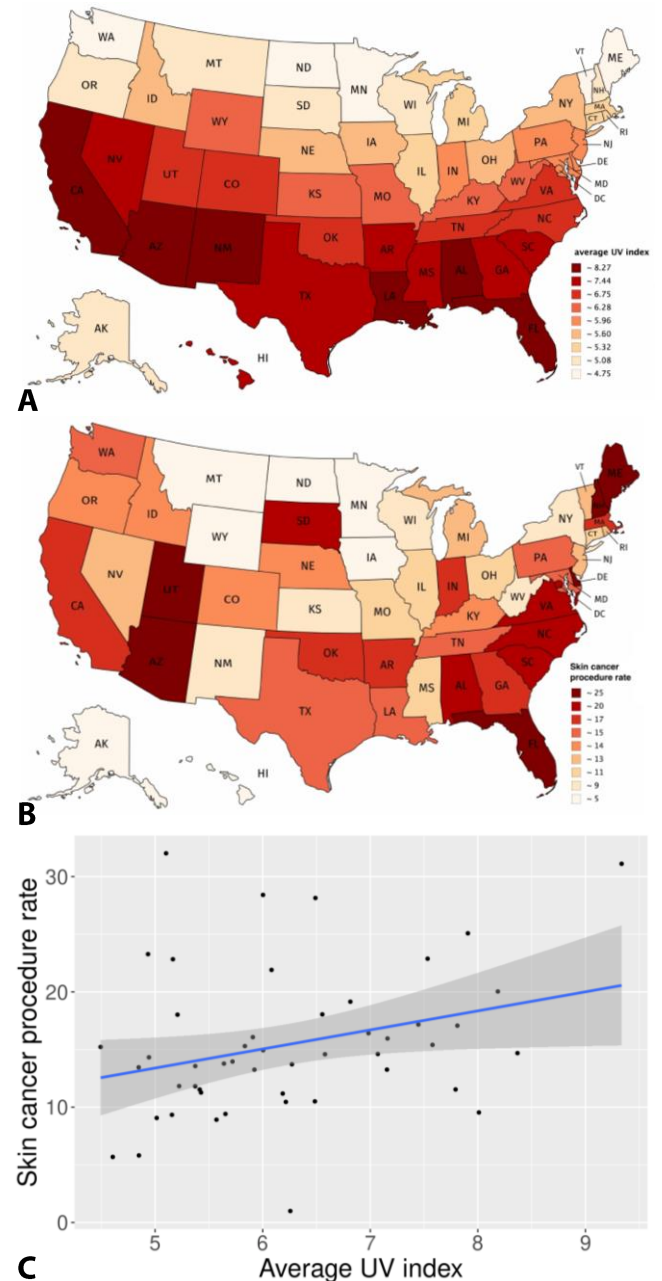


Figure 2. Correlation between average ultraviolet (UV) index and state-level skin cancer procedure utilization rate in the Medicare population. **A)** Map of average UV index in the United States. **B)** Map of skin cancer procedure rate in the United States. **C)** Scatterplot of average UV index versus skin cancer procedure rate and corresponding linear fit.

temperatures over 53°F [7]. In contrast, 6 of the 10 states with the lowest domestic migration have average temperatures of 48°F or less [8]. These migration patterns, along with anticipated further rise in temperatures will likely result in a continuing increase in skin cancer procedure rates for states with warmer weather. Our study is limited by use of

Medicare data which excludes younger and privately insured patients.

Potential conflicts of interest

The authors declare no conflicts of interest.

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