Combined impacts of climate change and population aging on indoor and outdoor heatstroke risks in Saitama City, Japan

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INTRODUCTION

Heatstroke has become a severe problem in the Saitama Prefecture of Japan. Saitama Prefecture experienced disastrous heat waves in 2018. On July 23, the daily maximum temperature in Kumagaya City reached 41.1°C, the highest record in Japan. As a result, 6,129 heatstroke patients were transported to hospitals from April to October (Source: Saitama Prefecture). 47.2% of the heatstroke patients were people aged 65 and over (65+). The local government is required to develop long-term adaptation strategies reflecting climate and population changes.

This study develops a statistical model of heatstroke frequency and predicts future heatstroke risk using climate and population scenarios. The target area is Saitama City, the capital of Saitama Prefecture. The prediction period is from 2026 to 2050. This study aims to find significant factors contributing to heatstroke frequency prediction and assess the combined impacts of climate change and population aging on heatstroke risk.

METHODS

Figure 1 illustrates the research methods. First, we construct the prediction model for monthly heatstroke frequency using historical data from 2010 to 2019. The prediction model is a regularized Poisson regression model with 18 explanatory variables and a population offset. The explanatory variables include month dummies, temperature indices, and electricity price index. The elastic net algorithm[1] is used for parameter estimation, which automatically removes unnecessary variables from the model. We obtained heatstroke patient records from Saitama City and classified them into six groups according to age (0-14, 15-64, and 65+) and location (indoor and outdoor). Each model parameter varies among the groups.

Second, we input climate and population scenarios to the prediction model and simulate the time variation of heatstroke frequency from 2026 to 2050. The climate scenario is generated from the statistically downscaled climate dataset developed by Dr. Koji Dairaku (University of Tsukuba). The RCP8.5 is assumed in this study. The population scenario is generated from the Japan SSP population dataset[2][3] developed by NIES.

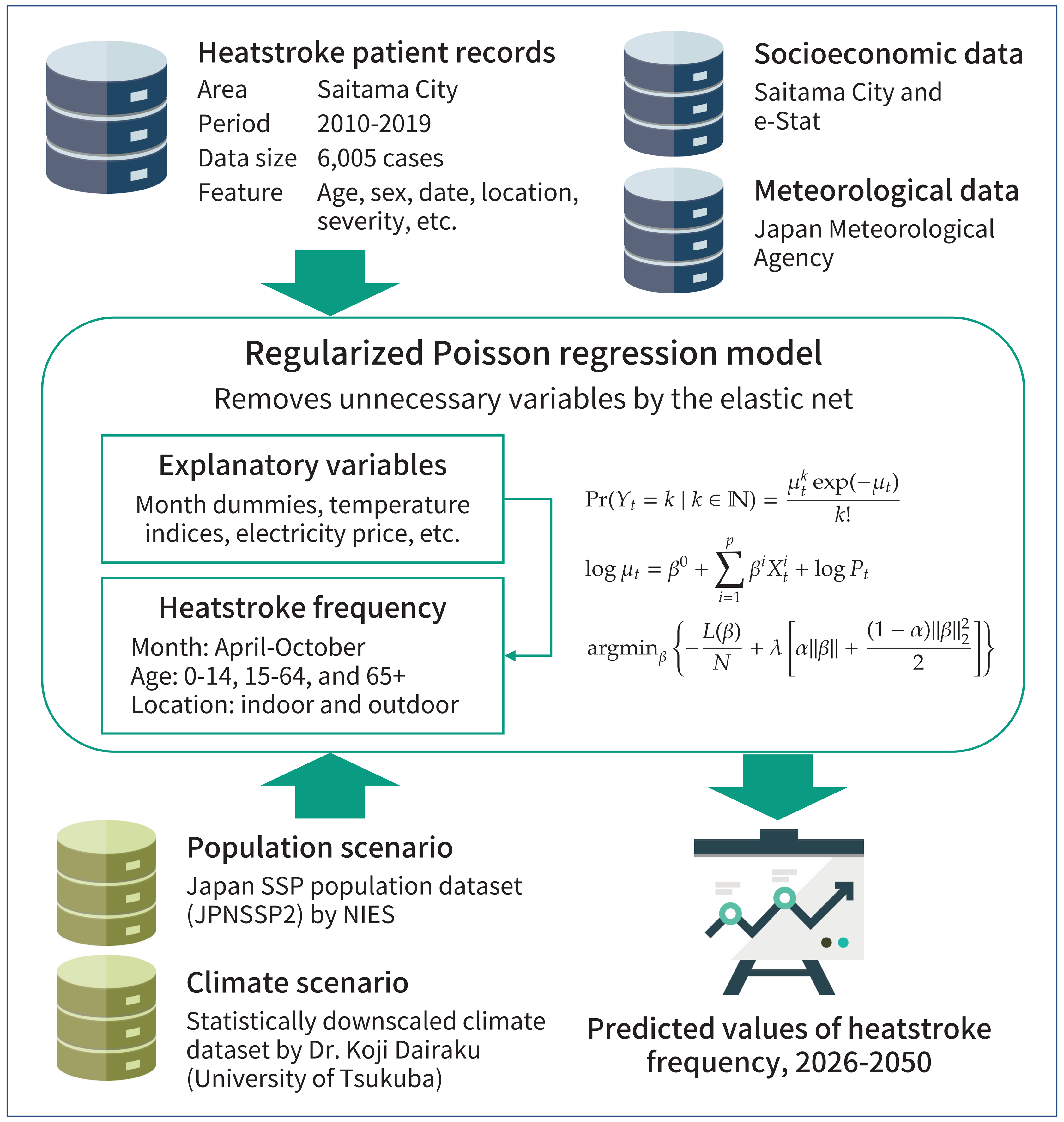

Figure 1: Research methods.

Explanatory variable	Indoor			Outdoor		
	Aged 0-14	Aged 15-64	Aged 65+	Aged 0-14	Aged 15-64	Aged 65+
AprDum		-0.747		-0.414	-0.951	
MayDum	0.465	0.360	0.362	0.205	-0.124	0.225
JunDum	-0.242	0.218			0.263	
JulDum	0.753	0.981	0.654	0.286	1.084	0.406
AugDum		0.504	0.084		0.741	0.028
SepDum		-0.242	-0.344	-0.022	0.138	-0.513
OctDum		-1.198	-0.959	-0.840	-1.280	-1.310
AveTmp		0.081		0.039	0.054	
AveMaxTmp				0.169	0.023	
AveMinTmp	0.286	0.118	0.281	0.004	0.061	0.258
NumDayMaxTmp25						
NumDayMaxTmp30					0.007	
NumDayMaxTmp35			0.060		0.012	
NumDayMinTmp25	0.024	0.014				
CDD22		0.003	0.001			
CDD30	0.041	0.015		0.053	0.060	0.030
ElecPriceIndex	0.017	0.020	0.014	0.005	0.012	0.015
ElecConsDum			0.023	0.406	0.395	0.094

Figure 2: Estimates of the regression coefficients.

RESULTS

Figure 2 shows the estimates of regression coefficients. The monthly average minimum temperature (AveMinTmp) and electricity price index (ElecPriceIndex) contribute to heatstroke frequency prediction for all the groups. Many previous studies have focused on the relationship between daytime temperature and heatstroke risk[4][5]. Our result suggests that night-time temperature is also a significant factor. Higher electricity prices may lead to higher heatstroke risk by discouraging people from using air conditioning.

Figure 3 shows the predicted values of annual heatstroke frequencies from 2026 to 2050. The black line is the mean of the model estimates in the 2010s, and the shaded area indicates the upper and lower limits of the model estimates. For all the climate scenarios, the heatstroke frequency will continue to increase and exceed the baseline. Most climate scenarios predict that disastrous heat waves will frequently occur and result in significantly high heatstroke frequencies. **Figure 4** shows changes in annual average heatstroke frequencies from the 2010s to the 2040s. Due to the combined effects of climate change and population aging, the indoor heatstroke frequency for the group aged 65+ will increase 2.89-fold, and the outdoor heatstroke frequency for the same group will increase 2.87-fold. The local government needs to develop adaptation strategies for aged people.

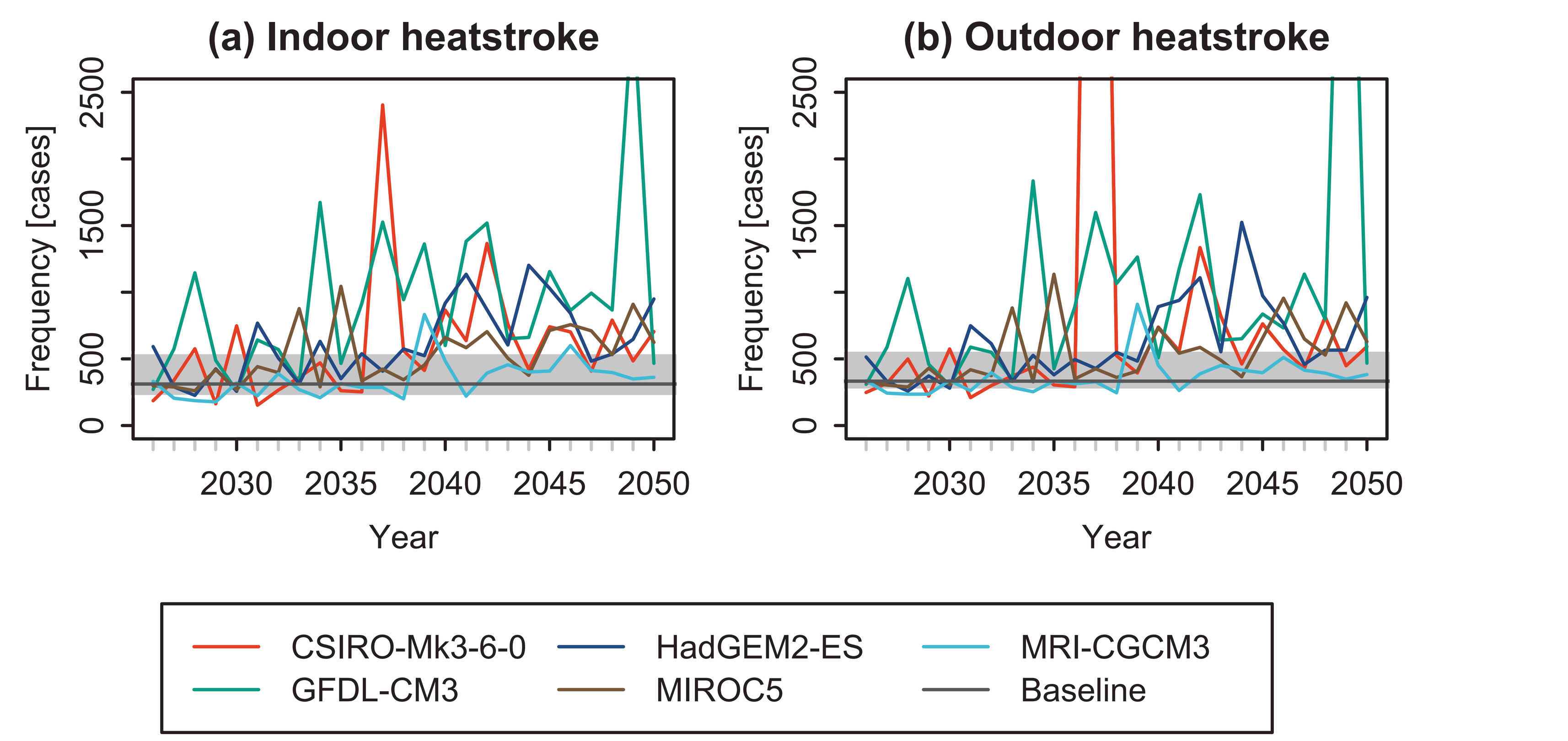

Figure 3: Predicted values of annual heatstroke frequencies, 2026-2050.

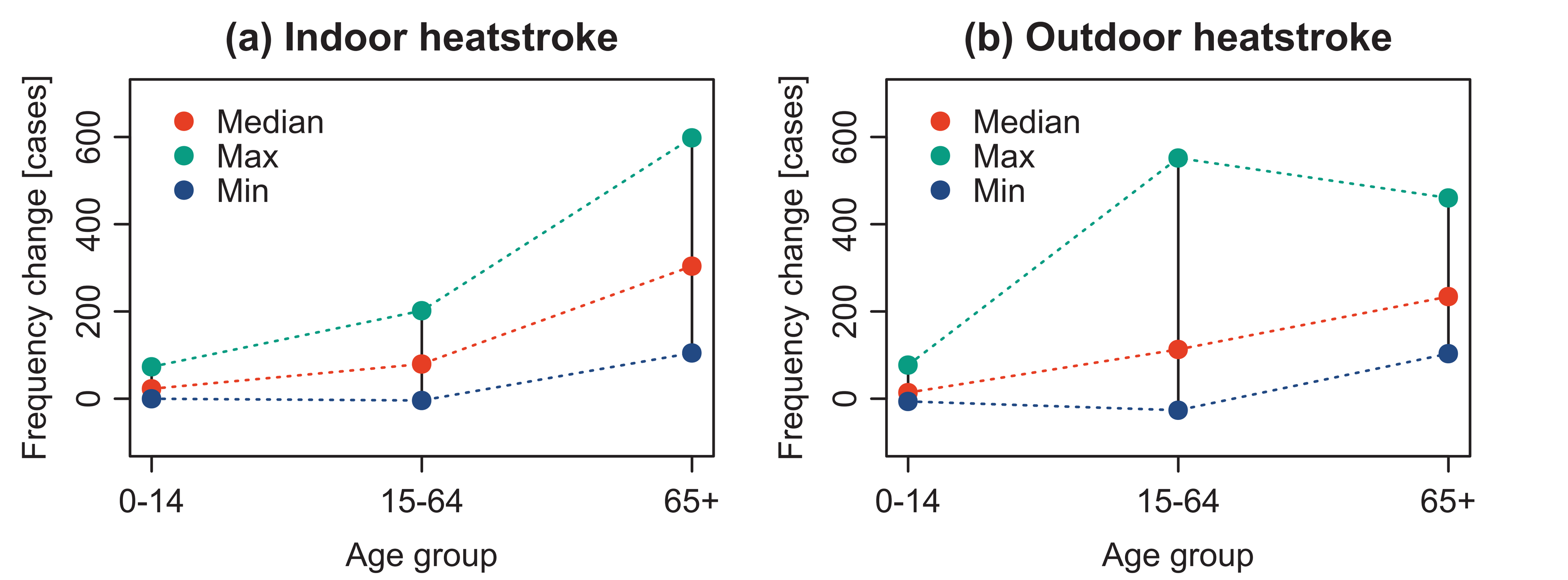

Figure 4: Changes in annual average heatstroke frequencies from the 2010s to the 2040s.

ACKNOWLEDGMENTS

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