Projection of impacts on ambulance transport system and economic burden under extremely high temperatures induced by climate change

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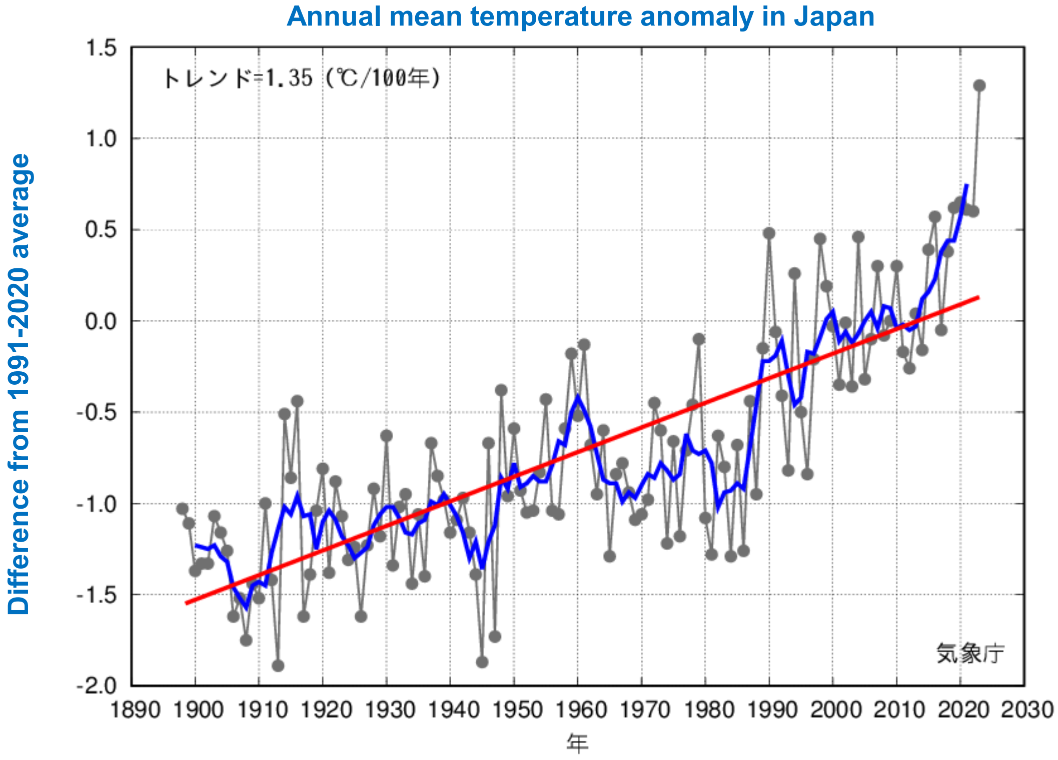
1. Introduction

■ Temperature changes in Japan

• **2023**: the hottest year since the statistics began (1898)

✓ Average annual temperature rises at a rate of **1.35°C/100 years**.

✓ Hottest years in Japan
①2023 (+1.29℃)
②2020 (+0.65℃)
③2019 (+0.62℃)
④2021 (+0.61℃)
⑤2022 (+0.60℃)

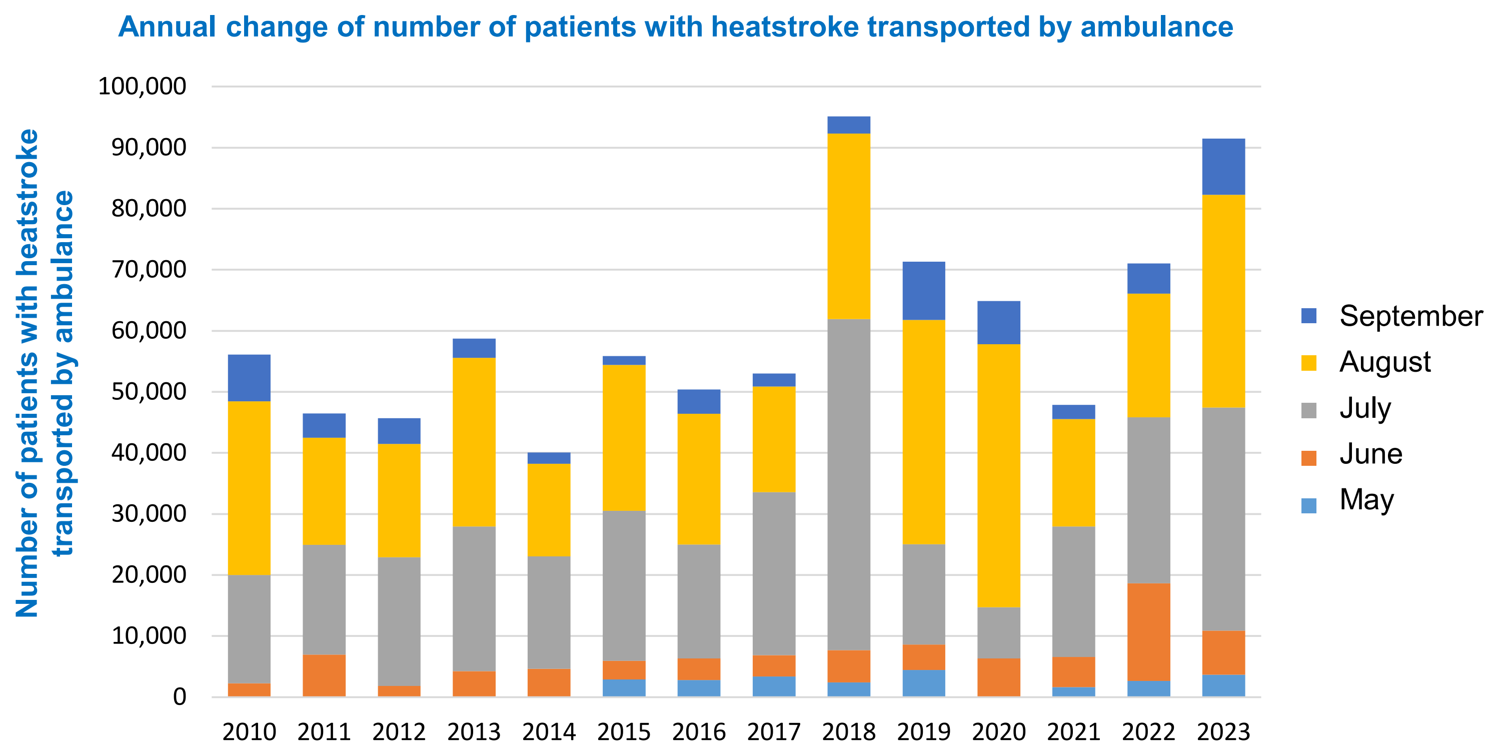


Source：JMA website (http://www.data.jma.go.jp/cpdinfo/temp/an_jpn.html)

1. Introduction

■ Number of patients with heatstroke transported by ambulance

- Heatstroke has become an increasingly serious problem in Japan as temperatures have risen due to heat islands and climate change.
- Heatstroke will increase further in the future because of climate change.



Source：FDMA data（https://www.fdma.go.jp/disaster/heatstroke）

2. Objective

- Heatstroke is already a serious problem in Japan because of heat islands and climate change.
- If extreme temperatures become more severe and frequent due to climate change, heatstroke will occur as never before.
  - ➢ The increase in heatstroke would have a serious impact on the medical supply system.
  - ➢ **Is it possible to transport patients with heatstroke by available ambulances to hospital?**

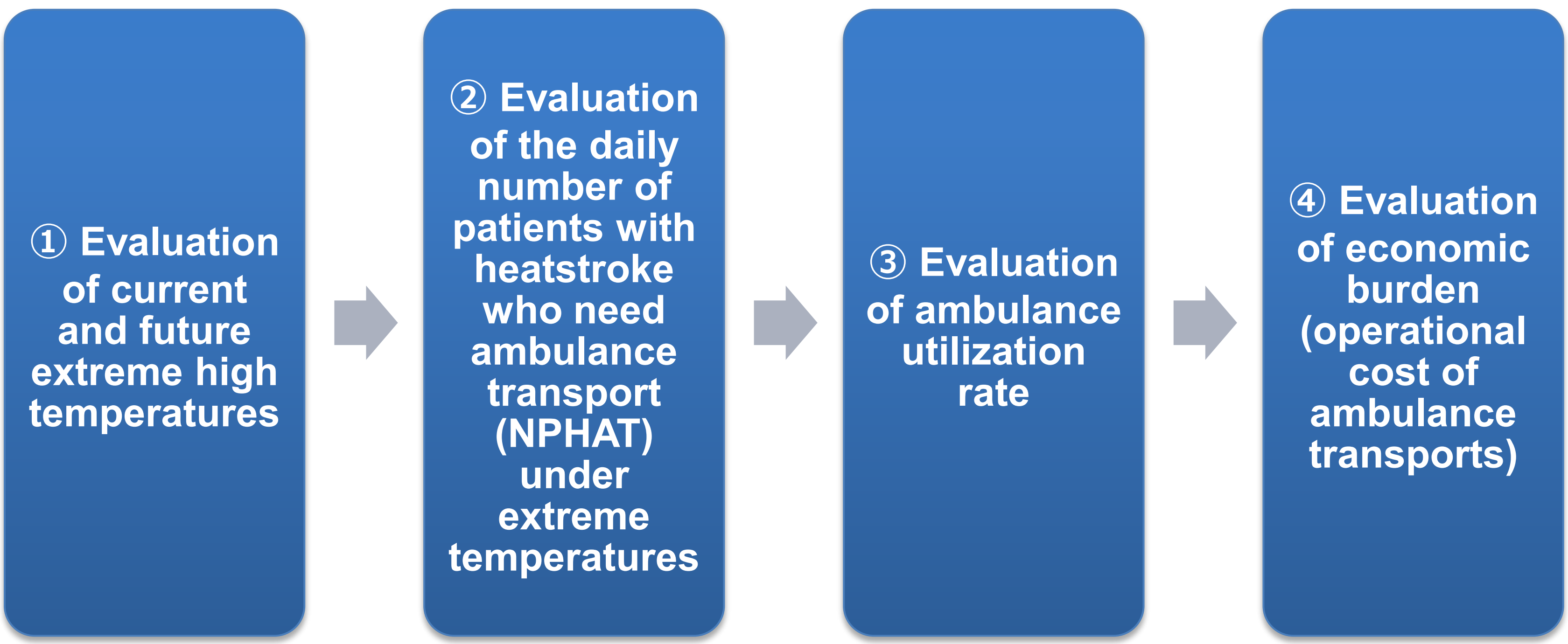
⇒ Currently, study on the health impacts of extreme temperature is limited.

- **To evaluate the impact on the medical supply system in terms of ambulance utilization rate under extreme temperature**

3. Data and method

■ Study flow

- The study design is shown below.
- The target region is **Tokyo**.



3. Data and method

■ Data

- **Climate prediction information**
  - ✓ **Climate scenarios**: 5 climate models (MIROC6, MRI-ESM2-0, ACCESS-CM2, IPSL-CM6A-LR, MPI-ESM1-2-HR)
  - ✓ **Socio-economic and emission scenarios**: 3 scenarios (SSP126, SSP245, SSP585)

    ⇒ 5 × 3 = **15 scenarios**
  - ✓ **Evaluation period**: Base year (1985-2014), mid 21C (2021-2050), late 21C (2071-2100)

  ➢ Data source: Bias corrected climate scenarios over Japan based on CDFDM method using CMIP6 from NIES

- **Heatstroke data**
  - ✓ **Age group**: 7-17 y, 18-64 y, ≥65 y

  ➢ Data source: Fire and Disaster Management Agency

① Evaluation of current and future extreme high temp → ② Evaluation of the NPHAT under extreme temperatures → ③ Evaluation of ambulance utilization rate → ④ Evaluation of economic burden

3. Data and method

① Evaluation of current and future extreme high temperatures

- Extreme high temperature is defined as the daily maximum temperature that occurs **once every 50 years (50y temp)**.
- 50y temp is evaluated by fitting the **generalized extreme value (GEV)** distribution to the **daily maximum temperatures** in climate scenarios.
- **Non-stationarity** was taken into account to consider the temporal changes in temperature induced by climate change.

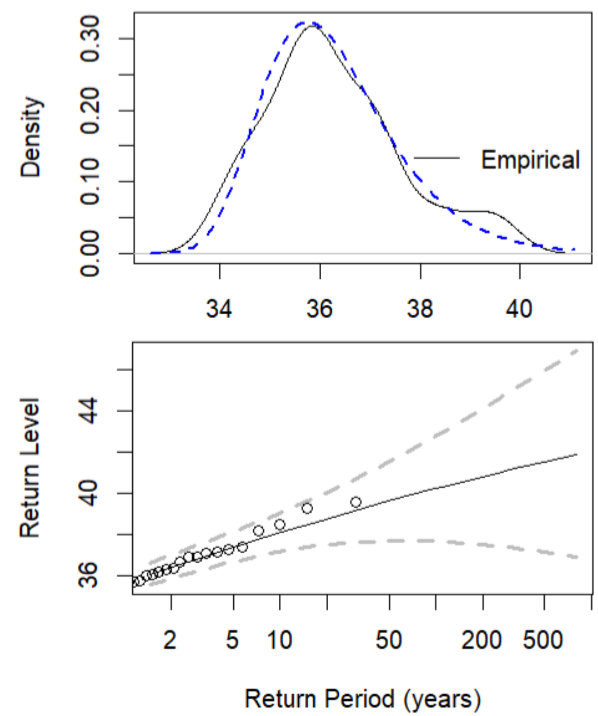
⇒ set μ as a linear function of time (years)

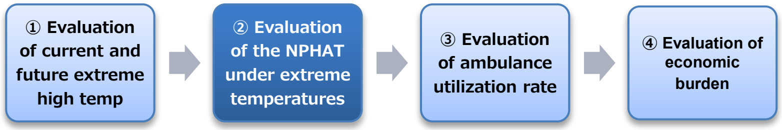
⇒ evaluate the need to take time into account by deviance

$$G(z) = \exp\left\{-\left[1+\xi\left(\frac{z-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}$$

$$1+\xi(z-\mu)/\sigma > 0.$$

μ: location, $\sigma > 0$: scale, ξ: shape



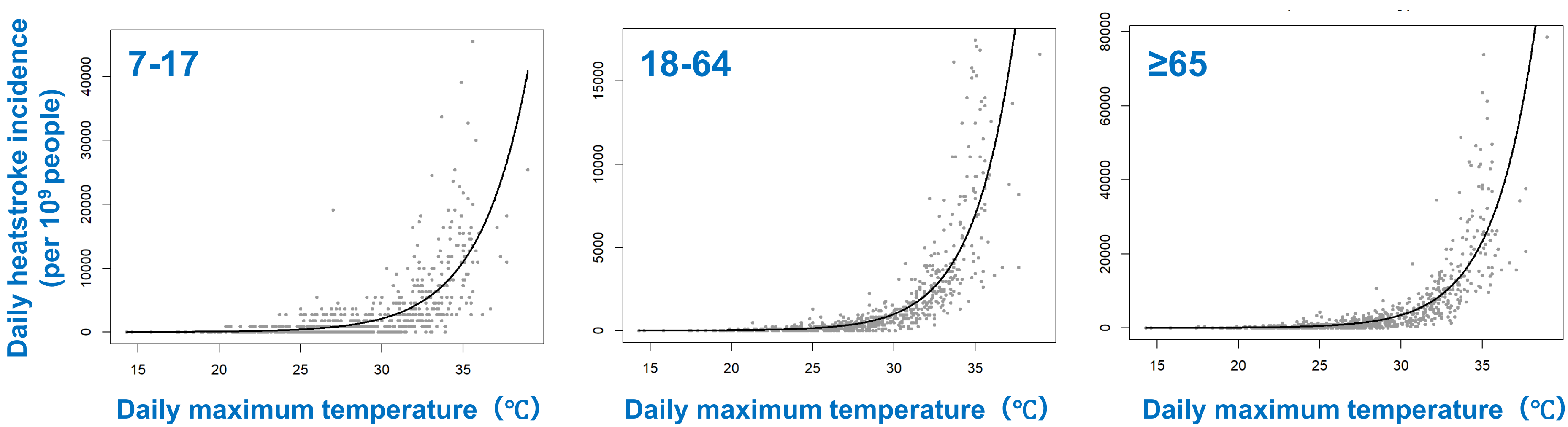


3. Data and method

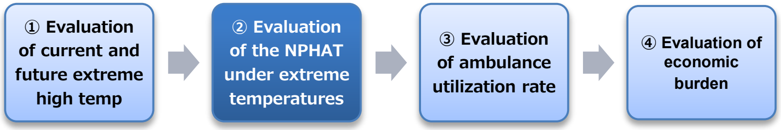
② Evaluation of the NPHAT under extreme temperatures

■ Risk function

- The association between daily heatstroke incidence and maximum temperature can be expressed as an **exponential function**.
- First, obtain the exponential function for each generation and then calculate the daily heatstroke incidence using the extreme temperatures obtained in ①.
- The NPHAT was calculated by multiplying the daily heatstroke incidence by the population.
  - ➢ **Future population**: fixed population case & changing population case



3. Data and method



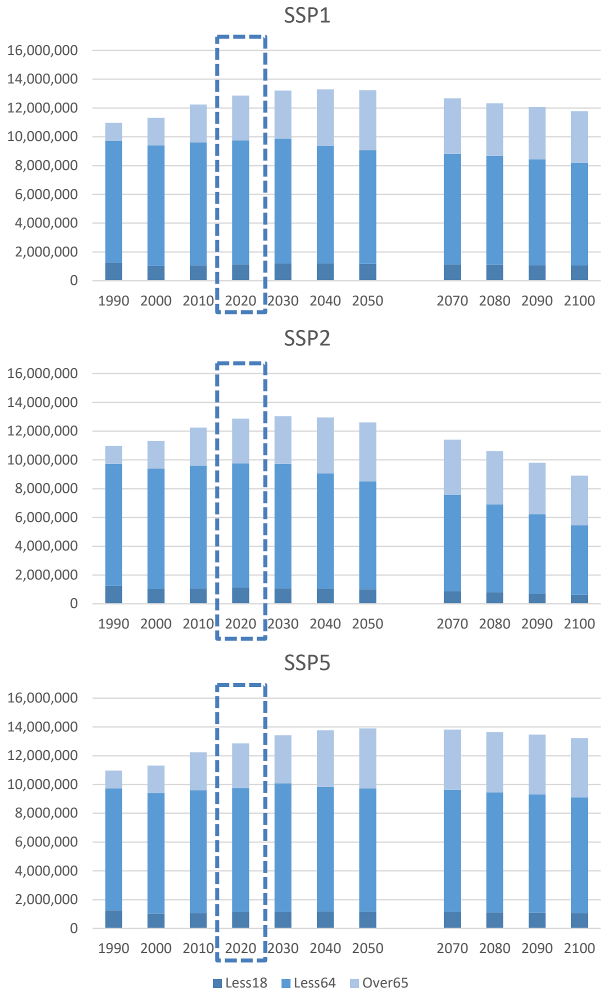
■ Future population

➢ Shared socio-economic pathways for Japan ver.2 from NIES

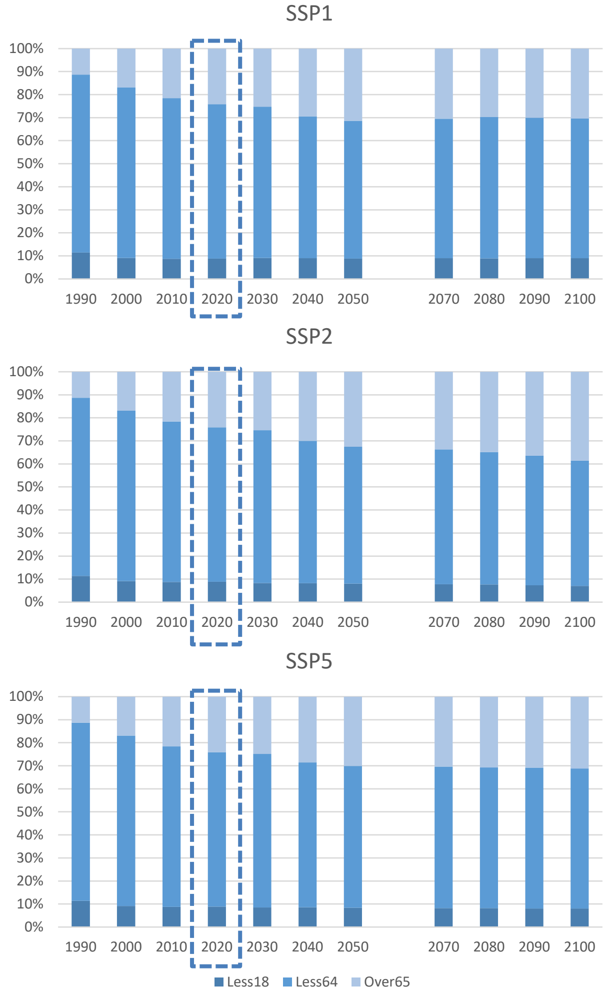
- In any scenario, the elderly increase in the mid and late 21C compared to 2020.
- In SSP2, the 18-64 y group decreases substantially in the late 21C.

	SSP1	SSP2	SSP5
Birth rate	**High**	Middle	Middle
Mortality rate	Middle	Middle	Middle
Immigration	Middle	Middle	**High**

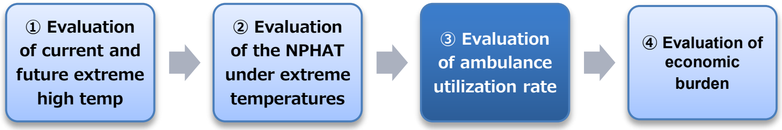
Population number [persons]



Population share [%]



3. Data and method



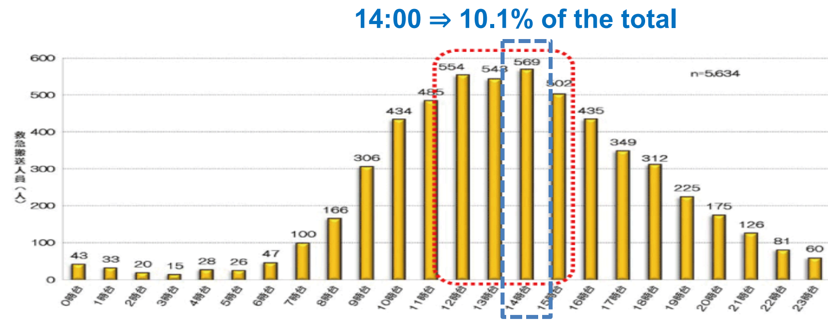
③ Evaluation of ambulance utilization rate

- Evaluation of ambulance utilization rate for patients with heatstroke at peak hour
  - ➢ **Peak hour**: 14:00 (in 2019)
  - ➢ **NPHAT at peak hour**:

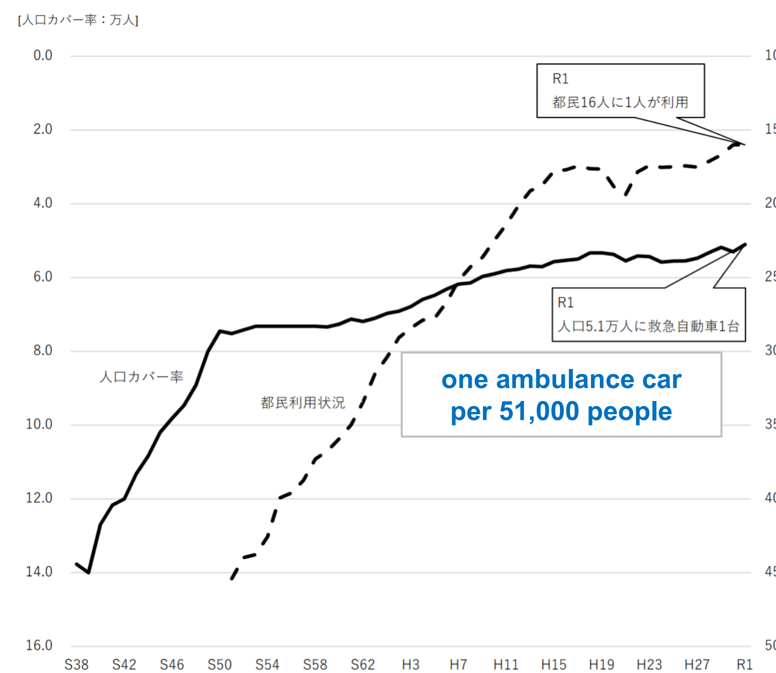
    *eq) Daily NPHAT × Percentage of NPHAT at 14:00**

    *10.1% at 14:00 in 2019

- The number of ambulances was adjusted to one per 51,000 population.
- Ambulances can be dispatched once per 1.5 hours.
- Ambulances are dispatched for heatstroke only.



Source: Tokyo Fire Department
（https://www.tfd.metro.tokyo.lg.jp/lfe/topics/202005/heat.html）



Source: Tokyo Fire Department report 2019

4. Results

■ Current and future 50y temp

- Evaluation of the need to consider the temporal (yearly) changes in temperature: $D = 2\{l_1(M_1) - l_0(M_0)\} > \text{or} < \chi_1(0.05)^2$
- Scenarios that need to take non-stationarity into account are indicated by the "●".
- The need was confirmed, especially in **SSP585**.

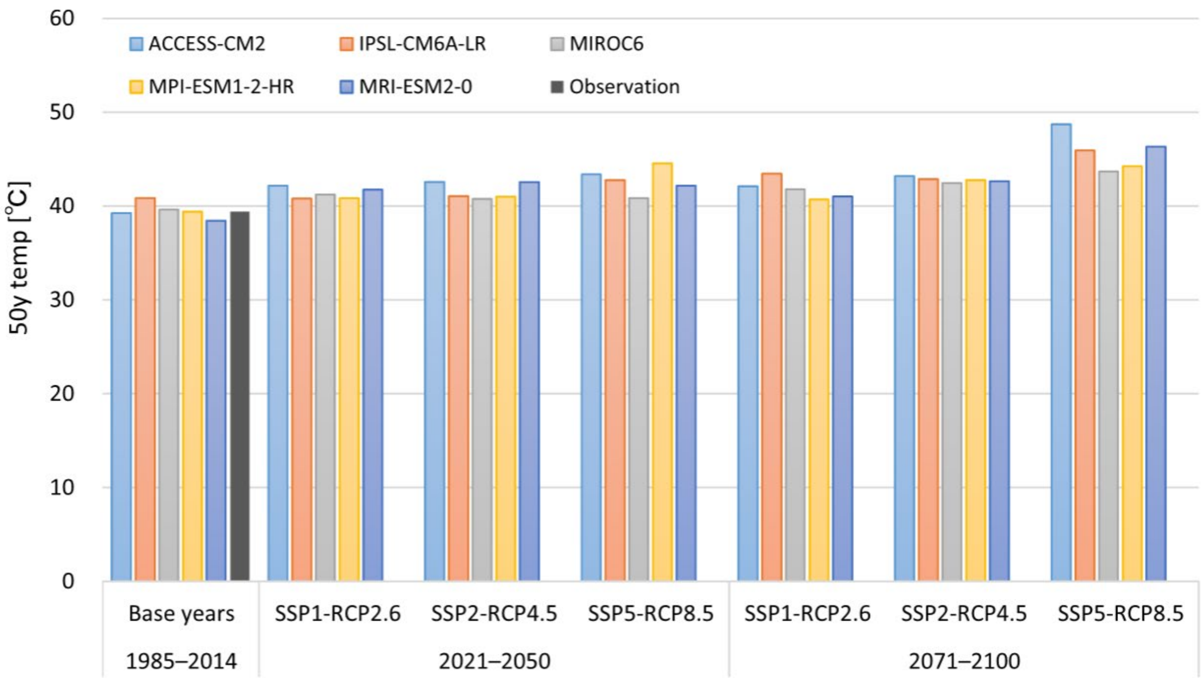
	hist 1985-2014	SSP126 2021-2050	SSP245 2021-2050	SSP585 2021-2050	SSP126 2071-2100	SSP245 2071-2100	SSP585 2071-2100
ACCESS-CM2			●				●
IPSL-CM6A-LR				●			●
MIROC6					●		
MPI-ESM1-2-HR				●			
MRI-ESM2-0							●

4. Results

■ Current and future 50y temp

- The 50y temp in **the base year** is **39.4 °C**.
- It will increase as
  - ➢ **40.8-44.5 °C** in **the mid 21C**
  - ➢ **40.7-48.7 °C** in **the late 21C**

Projected 50y temp



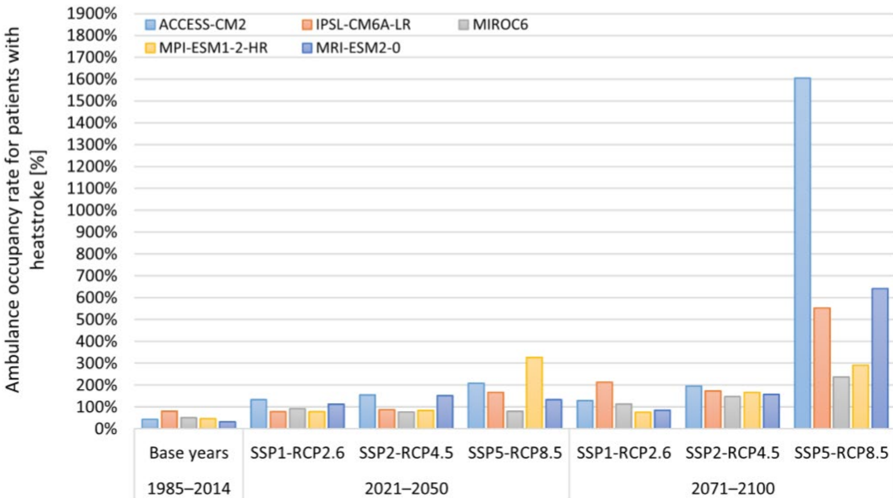
4. Results

■ Ambulance utilization rate

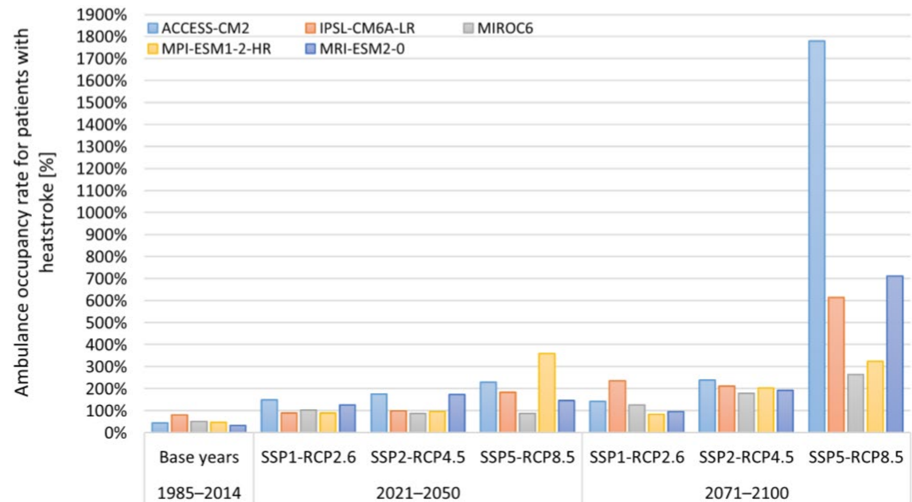
- The utilization rate in **the base year** is **50%**.
- For the changing population case across all scenarios, it will increase to
  - ➢ **145%** in **the mid 21C**
  - ➢ **319%** in **the late 21C**

Ambulance utilization rate > 100 %: not all patients with heatstroke can be transported by available ambulances.

- The utilization rate in the changing population case is higher than that in the fixed population case because of an increase in the elderly (≥65 y).



Ambulance utilization rate for fixed population case



Ambulance utilization rate for changing population case

5. Summary

- The extreme temperatures (50y temps) under climate change lead to a tightening of ambulance transport capacity and a greater economic burden.
- All ambulances were assumed to be available for only heatstroke. However, in reality, ambulances must be available for other reasons.

  ⇒ leads to a greater stringency in ambulance transport for patients with heatstroke

- There is a need to implement measures (adaptions) to prevent ambulance transport pressure.
  - **Pre-measures**: reduce the risk of heatstroke
    - ✓ The elderly account for 50% of all heatstroke ambulance transports and 80% of all heatstroke deaths.
    - ✓ An increase in the elderly under the aging society in Japan is expected.

    ⇒ **Measures for the elderly are crucial**.
  - **Post-measures**: appropriate use of ambulances, etc.

Reference

- Oka K., Honda Y., Hijioka Y. (2024) Prediction of ambulance transport system collapse under extremely high temperatures induced by climate change. *Environ. Res. Health.*, 2(035002):1-12.

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Thank you for your attentions

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