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EGU General Assembly 2024

Increasing climate change changes household medical expenditure

interactive presentations

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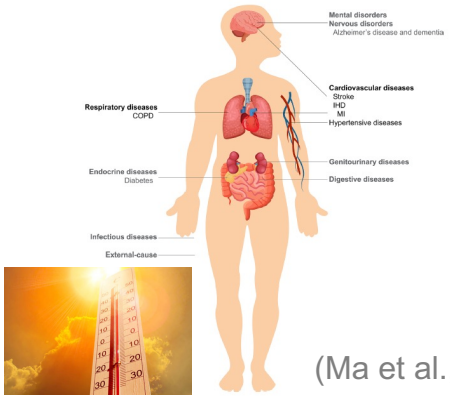
Zhu D, Liu M, Li R, et al. Increasing climate change changes household medical expenditure. EGU General Assembly 2024, EGU24-16105. https://doi.org/10.5194/egusphere-egu24-16105

Climate change is reshaping medical expenditure burden

Threatened Public Health

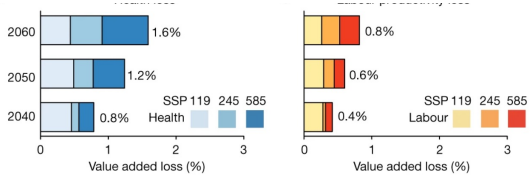


(Ma et al., 2020)

37% temperature-related deaths,
15% temperature-related illnesses
were attributed to anthropogenic climate change (Vicedo-Cabrera et al., 2021)

Health-related economic burdens

GDP loss



(Sun et al., 2024)

Known

Burdens on Society

Medical cost

Hospitalizations

Emergency department

(Wondmagegn et al., 2019)

?

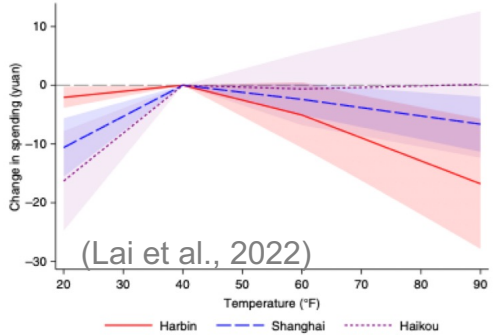
Unknown

Burdens on household finances

Physiological & socioeconomic adaptation will modify medical costs

Physiological

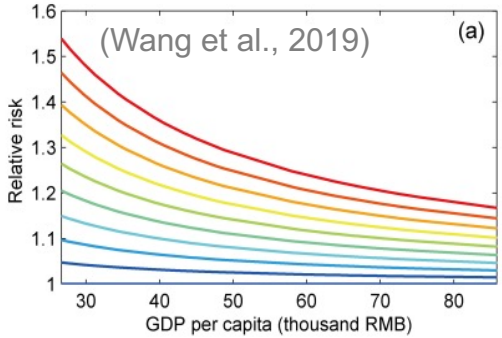
Drive residents to passively adapt to heat or cold after repeated exposure experience



Medical costs may reduce due to increased public resilience

Socioeconomic

Improved health infrastructure and affordability encourage residents to seek high-quality medical resources to avoid severe health consequences



Residents are willing to spend more money on medical treatment to protect their health

❑ Research question:

- What is the impact of climate change and adaptation on Chinese household medical expenditure?

❑ What we do:

- Build medical expenditure simulation models for 290 Chinese cities using Random Forest method
- Quantify the impact of climate change on medical expenditure in China under 4 SSP Scenarios
- Evaluate the effects of physiological and socioeconomic adaptations under 4 SSP Scenarios

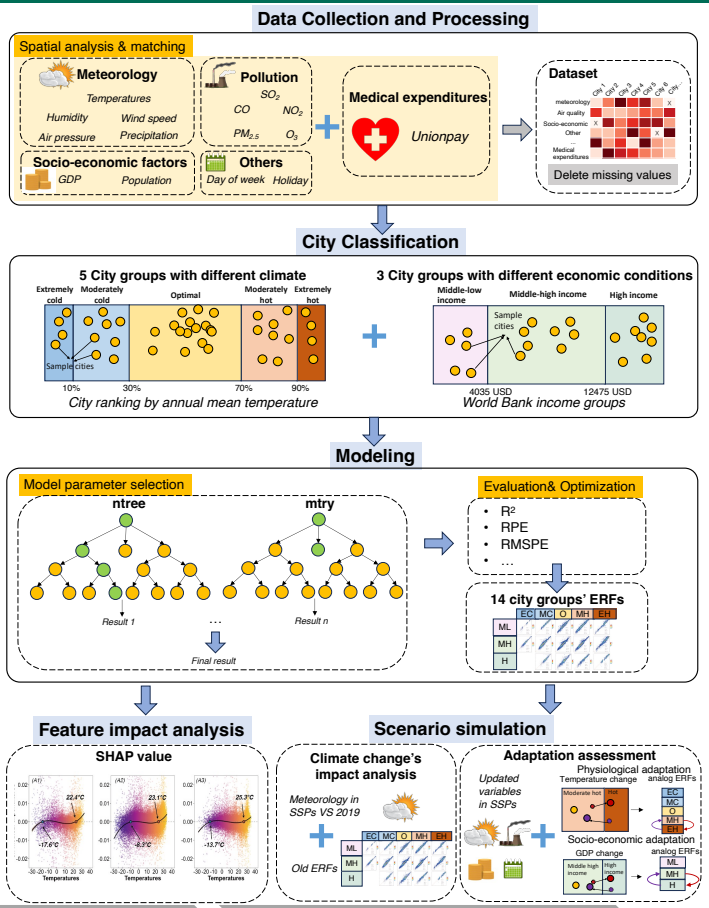
Framework and data

❑ Study framework:

- Establish daily medical expenditure simulation models (Random Forest models) for multiple cities in China and evaluate the net impact of climate change
- Simulate scenario-differentiated socioeconomic and physiological adaptations by applying analog ERFs

❑ Main dataset:

- Medical expenditure: daily fine-scale bank transaction records from China UnionPay
- Future meteorology: 20 GCMs from NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6)

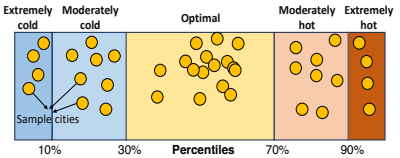


Medical expenditure simulation models and climate change's effects

❑ Classify cities to address the heterogeneity of vulnerability

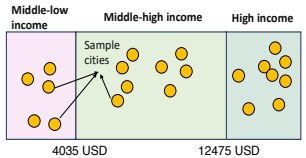
5 climatic city groups

based on 2010-2019 average temperatures



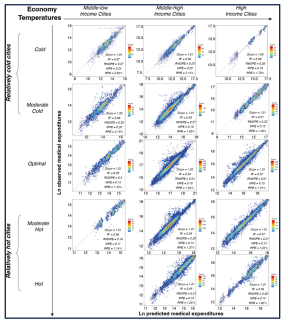
3 economic city groups

based on 2019 Per capita GDP



❑ Add muti-variables into random forest models to simulate medical expenditure

RF models of 14 city groups



- ✓ Meteorology: Temperature, Wind speed, Precipitation, Air pressure
- ✓ Air quality: $PM_{2.5}$, O_3, SO_2, NO_2, CO
- ✓ Socioeconomic data : Pop, GDP
- ✓ Day : Dow, Holiday

Model performance ✓ $R^2 \geq 0.83$, RPE ≤ 3.12%

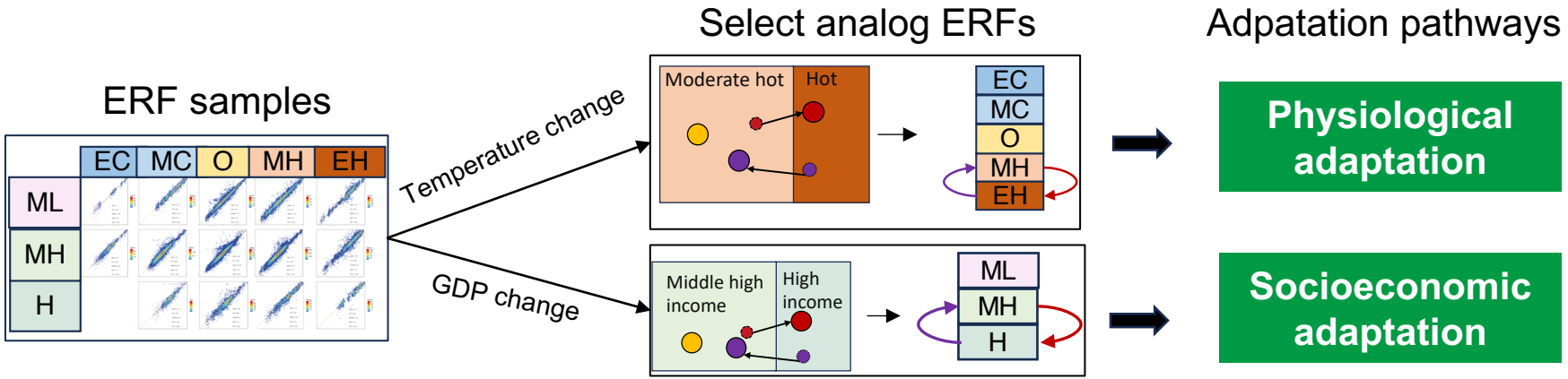
❑ Quantify climate change impacts using counterfactual scenarios

$$\text{Impacts}_{climate\ change} = f(Meteo_{SSP}, Air\ quality_{2019}, Socio_{2019}, Day_{2019}) - f(Meteo_{2019}, Air\ quality_{2019}, Socio_{2019}, Day_{2019})$$

Physiological & socioeconomic adaptation simulation

❑ Use analog ERFs to quantify adaptations

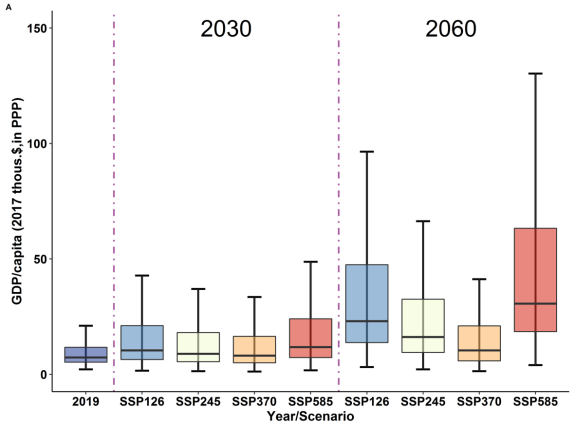
- **Assumption:** If cities' temperatures rise and economic conditions improve, their medical expenditure response to climate will also evolves and gradually resembles those of warmer and wealthier cities.
- **Methods:** analog ERFs (characterize the future vulnerability of cities and quantify adaptations based on their future temperatures and economic levels)



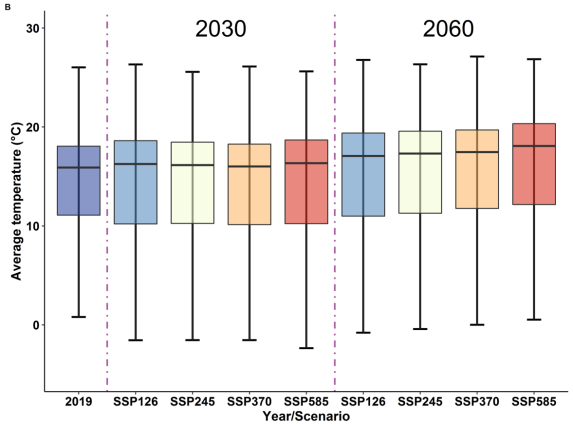
Quantify scenario-differentiated adaptations

❑ Scenario settings

- The extent of adaptations that each city can achieve is closely intertwined with its future temperature and economic levels under different scenarios
- **Target years:** 2030 and 2060 (SSP126, SSP245, SSP370 and SSP585)

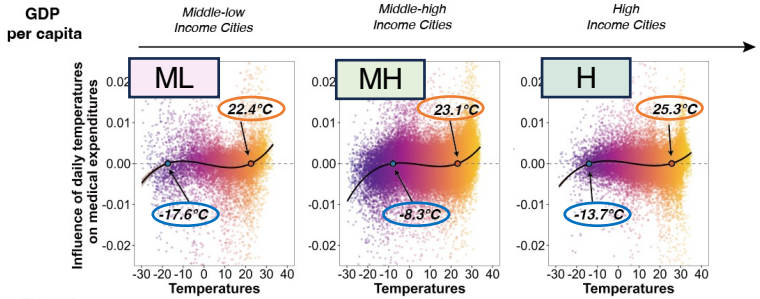


Distribution of per capita GDP among 290 cities



Distribution of daily average temperatures among 290 cities

Differential responses of medical costs to non-optimal temperatures across city groups with varied economic levels



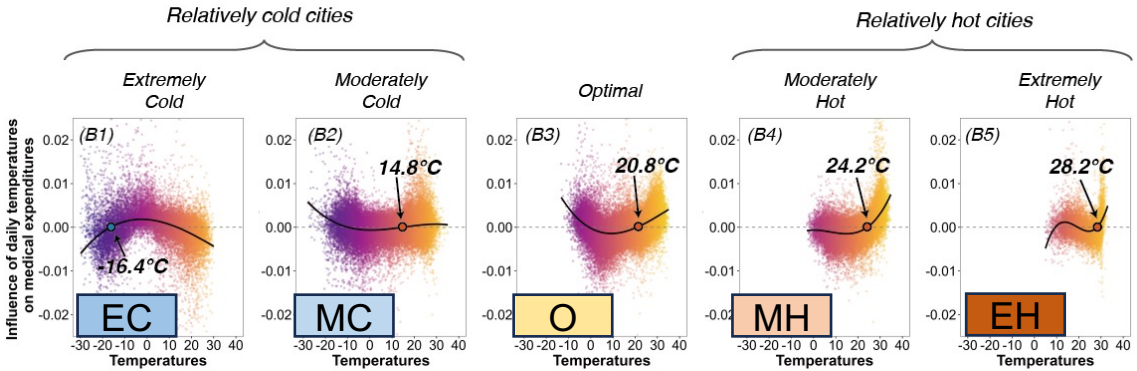
Marginal effects of daily average temperatures on medical expenditures among city groups (Shap values from Random Forest)

Heat: Higher-income cities have enhanced resilience to high temperatures. The threshold for increased medical expenditure due to heat continues to rise from ML (22.4℃) to MH (25.3℃)

Cold: The impacts of economic development are more complex

- Initially, the protective effects of winter heating will last for a longer duration: ML (< -17.6℃) →MH (< -8.3℃)
- Then, more proactive medical consumption willingness will overwhelms the protective effects : MH (< -8.3℃) → H (< -13.7℃)

Differential response of medical costs to non-optimal temperatures across city groups with varied climatic conditions



Marginal effects of daily average temperatures on medical expenditures among city groups (Shap values from Random Forest)

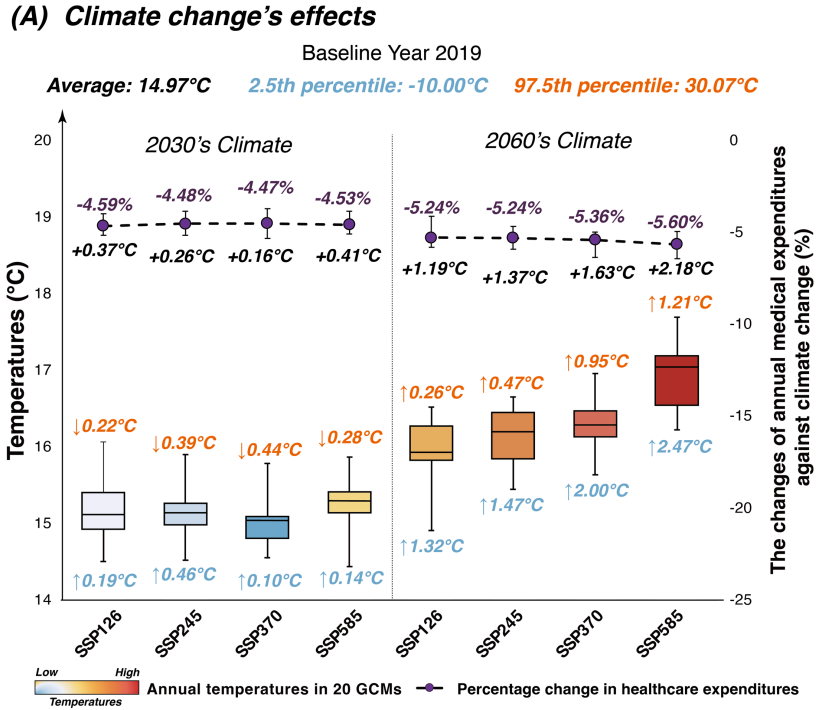
Heat: Hot cities have limited adaptation to heat

- Warmer cities have wider ranges of physiological adaptation: O (<20.8℃), MH (<24.2℃), EH (<28.2℃)
- Once the limits are exceeded, high temperatures can significantly stimulate the medical expenditures: Shaper curves beyond the thresholds

Cold: Cold cities demonstrate less vulnerability to low temperature

- The contribution of low temperatures to the growth of medical expenditures decreases (O→MC), and protective effects may even emerge: EC (< -16.4℃)

Climate change will reduce future annual medical costs



Impacts of climate change on temperatures and medical expenditure

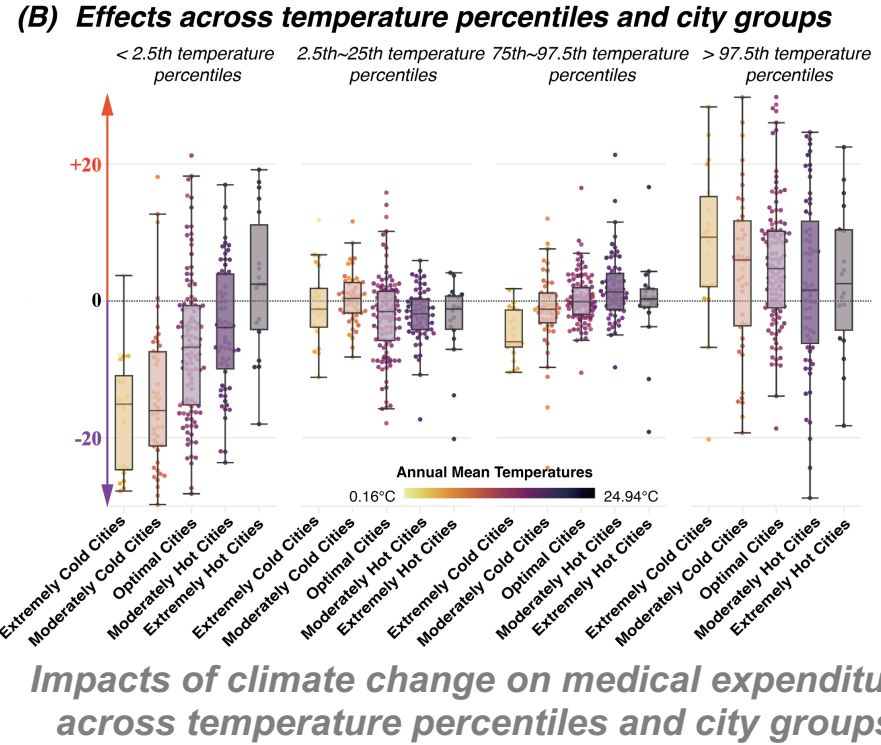
❑ 2030 VS 2019

- As the annual average temperature rises by 0.16 ℃ to 0.41℃, medical expenditure in China are projected to decrease by 4.47~4.58%

❑ 2060 VS 2019

- With a further increase in temperature to 1.19 ℃ to 2.18 ℃, the national medical expenditure are projected to decrease by 5.24~5.60%

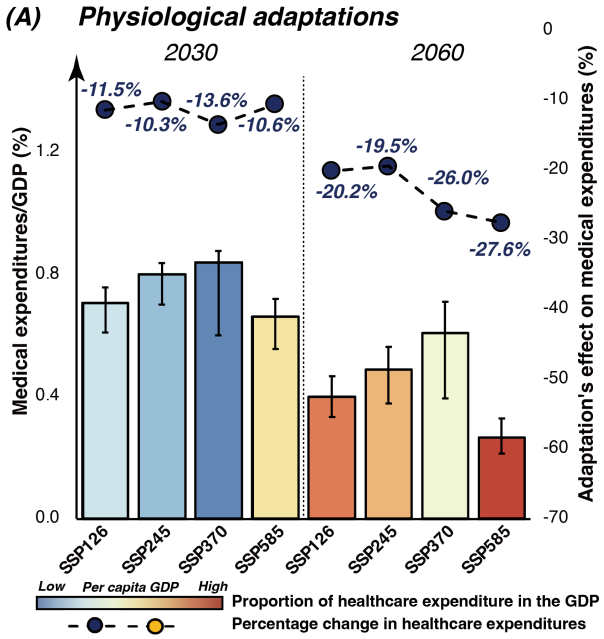
Medical costs surge in cold cities during heatwaves



Impacts of climate change on medical expenditure across temperature percentiles and city groups

- Most cities experience decreases in daily medical expenditure against extremely low temperatures: -17.8% (EC), -15.2% (MC), -6.8% (O), -4.5% (MH)
- Most cities (especially in cold cities) experience a surge in household medical costs against extremely high temperatures: +8.8% (EC), + 8.3% (MC), +7.4% (O), +3.1% (MH), +5.1% (EH)

Adaptations exhibit predominated impacts——Physiological

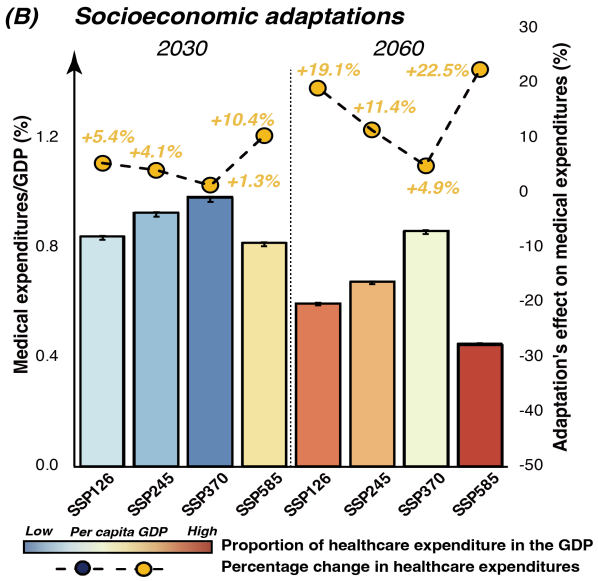


Impacts of physiological adaptation on future medical expenditures against climate change

❑ Physiological adaptations are expected to play a crucial role in alleviating future household medical expenditure pressures

- By 2030, physiological adaptations are projected to reduce medical expenditure against climate change by 10.3% to 13.6% under four SSPs.
- By 2060, the reductions expand to 19.5% to 27.6%.

Adaptations exhibit predominated impacts——Socioeconomic



Impacts of socioeconomic adaptation on future medical expenditures against climate change

☐ Socio-economic adaptation stimulates the growth of medical expenditure

- Household medical expenditure are projected to increase by 1.3% to 10.4% in 2030 under four SSPs and by 4.9% to 22.5% in 2060.

☐ Socio-economic adaptation may alleviate household financial burden

- The relative burden represented by the ratio of medical expenditure to per-capita GDP tends to be lower in wealthier scenarios.

Discussion and conclusions

- While leveraging socioeconomic adaptation to enhance heat tolerance, urban administrators must remain vigilant against the overutilization of medical resources in cold days.
- Physiological adaptation can effectively mitigate the pressure on medical expenses. In addition to passive enhancement through repeated exposure, urban administrators can guide physiological adaptation to play a more positive role through behavior instruction measures such as raising awareness of exposure risks, adjusting work hours.
- Improving heatwave early warning systems is crucial for addressing the health risks of climate change, especially for cold cities.

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Thank you!