

# **Evaluating Temporal Variations in Access to Multi-Tier Hospitals using Personal Vehicles and Public Transit: Implications for Healthcare Equity**

Ziqi Yang, PhD candidate

Urban Mobility Institute, Tongji University



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## Healthcare Equity

- Equity is the absence of unfair, avoidable or remediable differences among groups of people.
- Health is a fundamental human right.
- Healthcare equity is achieved when everyone can attain their full potential for health and well-being.



## ■ Background

### Five key dimensions to assess healthcare equity:

- Affordability: the costs associated with healthcare usage
- Acceptability: compliance with and satisfaction from healthcare services
- Availability: adequacy of healthcare service provision
- Accommodation: the appropriateness and suitability of healthcare services
- **Accessibility: ease of travel to healthcare providers using any mode of transportation**

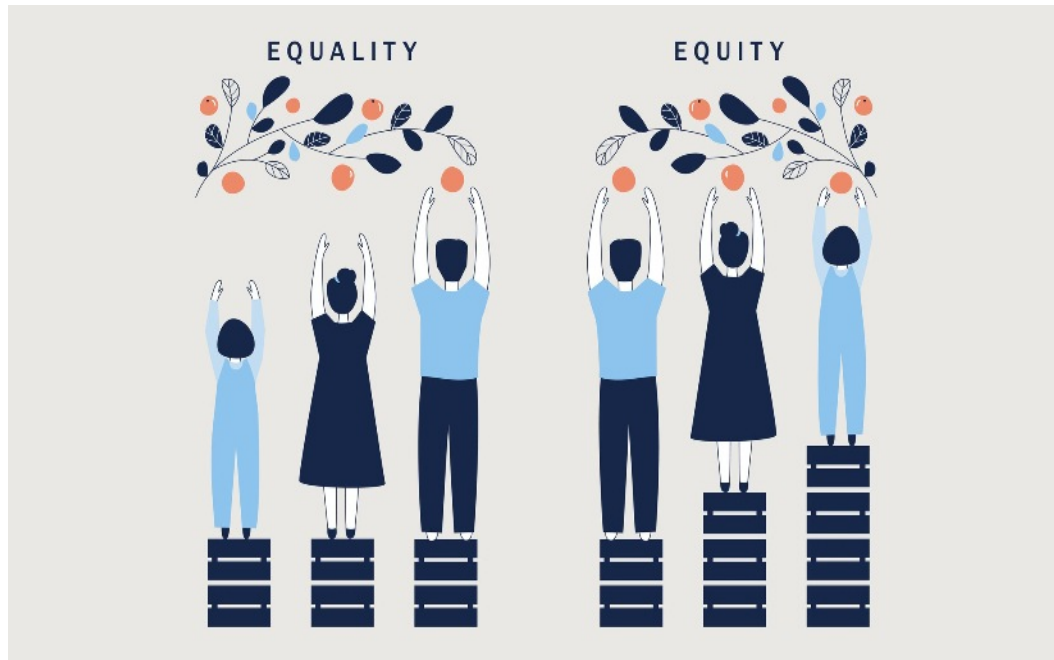
## ■ Background

### Accessibility Equity



Horizontal Equity

Vertical Equity



Achieving accessibility equity aim is to mitigate disparities in access to healthcare services for individuals with comparable needs (*horizontal equity*) and/or to provide preferential treatment for those with greater needs (*vertical equity*) by strategically allocating or reallocating healthcare and transportation resources.

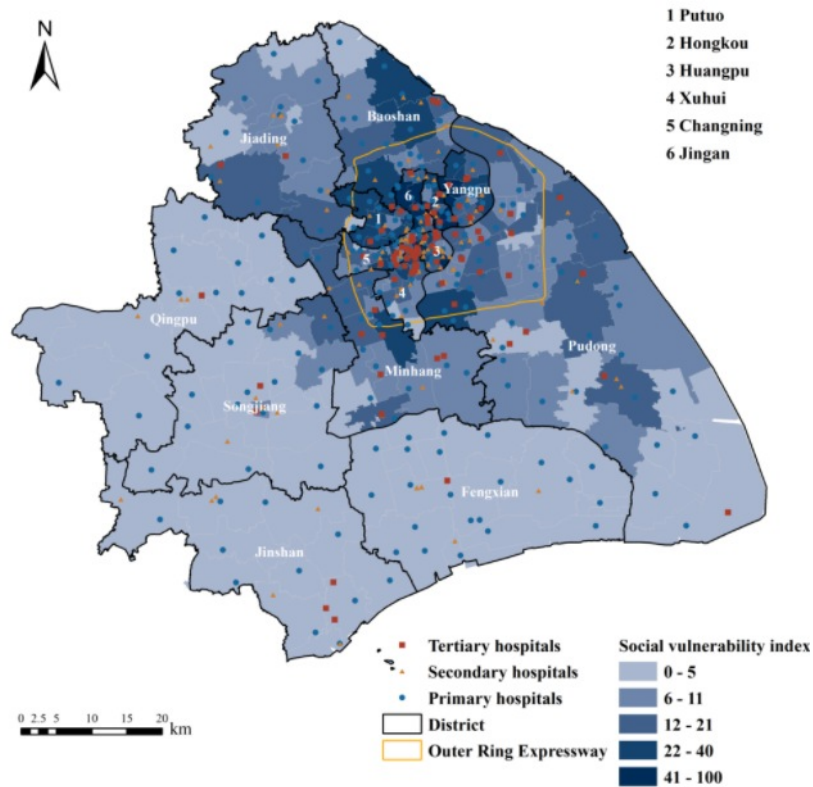


## **We want to answer two questions:**

- How can we devise effective measurements of healthcare accessibility to identify regional disparities?
- How can we accurately quantify healthcare equity to understand the potential effectiveness of different strategies aimed at promoting equity?

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## ■ Study region and data



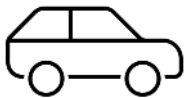
- Population: 24.9 million people (2020), 90% in urban areas
- Economy: GDP grew 8x from 2000 to 2022
- Healthcare: 451 hospitals
- Transport: One of world's biggest transit network

## ■ Focus



**3** tiers of hospitals:

- 91 tertiary, 127 secondary, and 233 primary hospitals



**2** types of modes

- Personal Vehicles (PV) and Public Transit (PT)

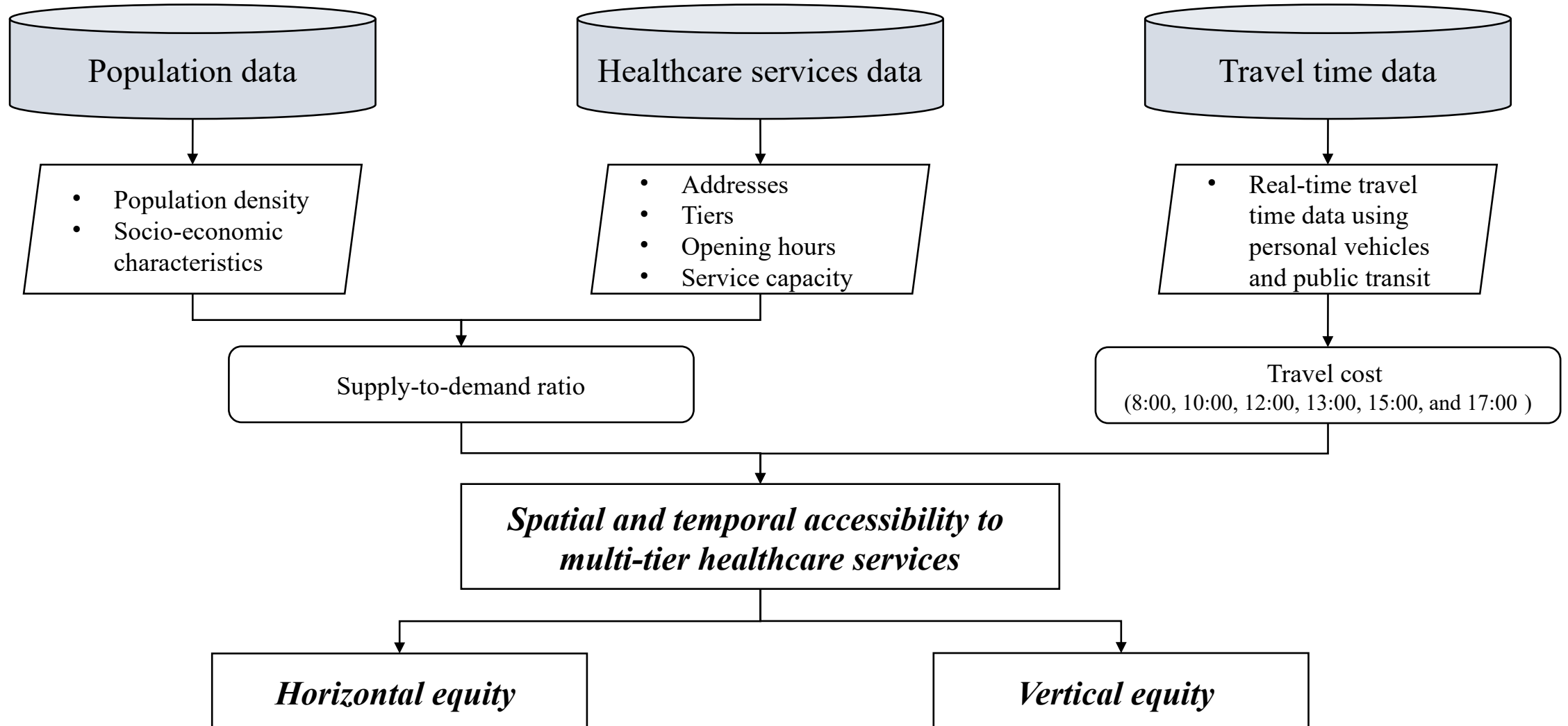


**6** time points:

- 8:00, 10:00, 12:00, 13:00, 15:00, and 17:00

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## ■ Framework



## ■ Methods

- Accessibility: Gaussian two-step floating catchment area method

$$R_i = \frac{S_i}{\sum_{j \in \{d_{ij} \leq d_0\}} D_j W_{ij}}$$

$$A_j = \sum_{i \in \{d_{ij} \leq d_0\}} R_i W_{ij}$$

$$W_{ij} = \begin{cases} \frac{e^{-\left(\frac{1}{2}\right) * \left(\frac{d_{ij}}{d_0}\right)^2} - e^{-\left(\frac{1}{2}\right)}}{1 - e^{-\left(\frac{1}{2}\right)}}, & \text{if } d_{ij} \leq d_0 \\ 0, & \text{if } d_{ij} > d_0 \end{cases}$$

**6** time points:

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## ■ Methods

- Horizontal equity: Gini coefficient

$$GC = \frac{\sum_{i=1}^n \sum_{k=1}^n |A_i - A_k|}{2n^2 \bar{A}}$$

- Vertical equity: Spearman's rank correlation index

$$r(X, Y) = \frac{Cov(X, Y)}{\sqrt{Var[X] Var[Y]}}$$

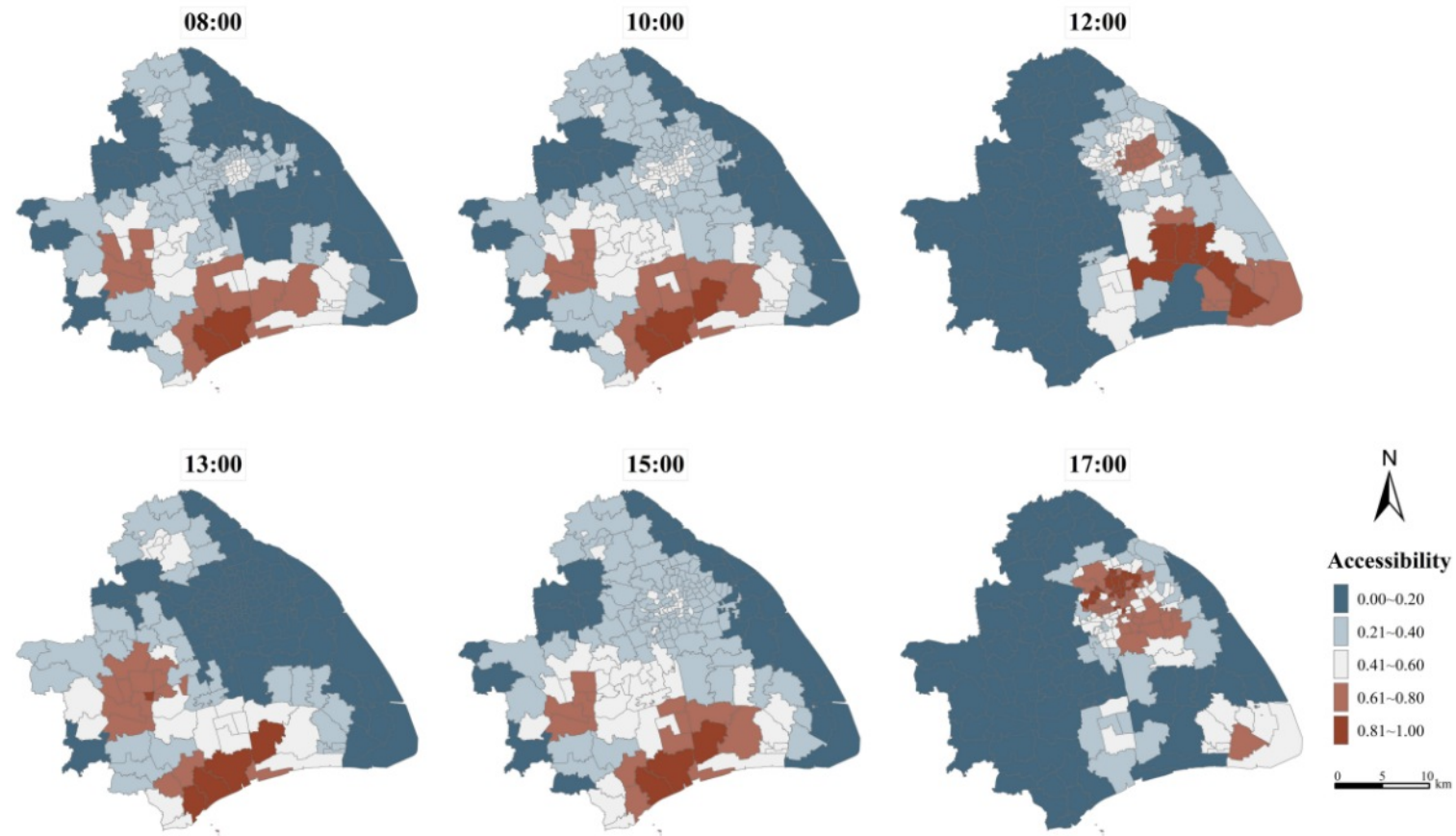
Evaluation index system of social vulnerability index to healthcare demand.

Item	Element	Abbreviation	Indices
Social vulnerability index (SVI)	Exposure index (EI)	E1	Population density (10,000 persons/km <sup>2</sup> )
		E2	Regional GDP/regional area (10 <sup>9</sup> yuan/km <sup>2</sup> )
		E3	Capital invested in the fixed assets/regional area (10 <sup>9</sup> yuan/km <sup>2</sup> )
	Sensitivity index (SI)	S1	Percentage of female resident population (%)
		S2	Percentage of population with age > 65 (%)
		S3	Percentage of population with age < 14 (%)
		S4	Percentage of the immigration (%)
		S5	Percentage of minority population (non-Han groups in China) (%)
		S6	Illiteracy rate (%)
		S7	Unemployment rate of population 15 years or older (%)
		S8	Divorce rate of population 15 years or older (%)
		S9	Percentage of laborers working in primary sector industries (%)
		S10	Percentage of households without piped water (%)
		S11	Percentage of households without elevator (%)
	Capacity index (CI)	C1	Rail transit mileage (km)
		C2	Car ownership (cars per capita)
		C3	Per capita GDP (10 <sup>5</sup> yuan/persons)
		C4	Capita disposable income (yuan)
		C5	Number of beds in medical institutions per 1000 resident population (beds per capita)
		C6	Number of health technicians per 1000 resident population (technicians per capita)
		C7	Number of medical institutions per 1000 resident population (hospitals per capita)

Social vulnerability index

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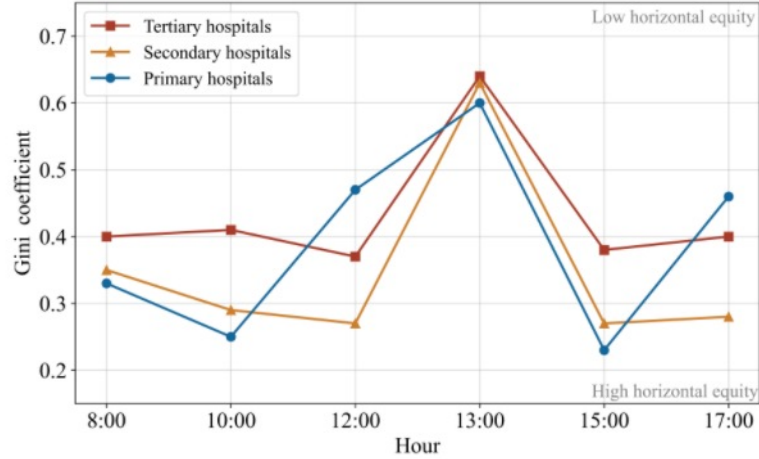
## ■ Results



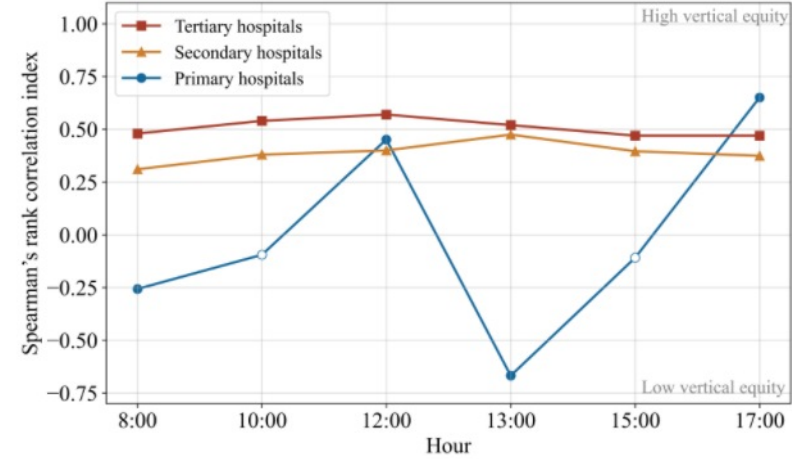
PV to secondary hospitals

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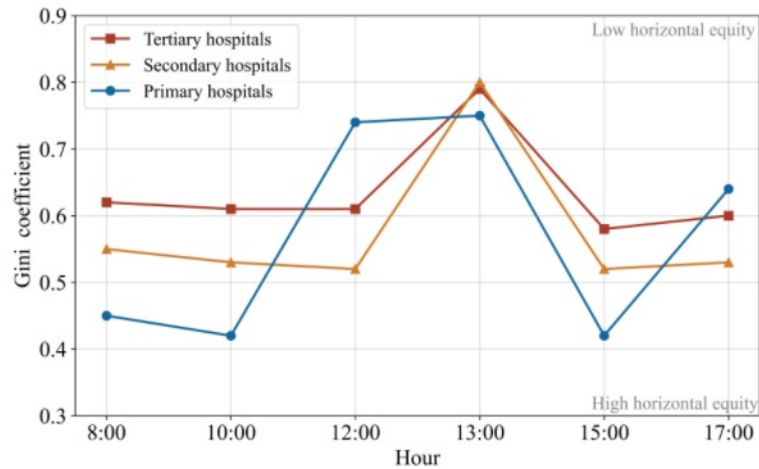
## ■ Results



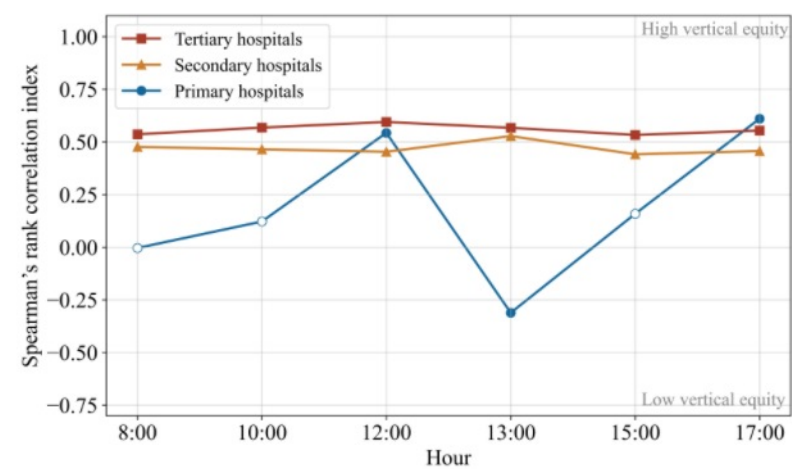
PV\_Gini



PV\_Spearman



PT\_Gini



PT\_Spearman

## ■ Results

1. Notable temporal fluctuations in healthcare accessibility, especially for PT, and their significant impact on both horizontal and vertical equity due to varying travel times and hospital schedules
2. Larger disparities in higher-tier hospital accessibility compared to lower-tier ones
3. Greater horizontal equity using PV-based accessibility and higher vertical equity using PT-based accessibility

## ■ Policy implications

1. Dedicated bus routes and customized shuttles
2. Telehealth for remote and underserved areas
3. Integrating equity into hospital site selection
4. Attracting medical practitioners to rural areas
5. Community outreach and education programs





## ■ Contribution

- Incorporating the temporal dimension into the accessibility evaluation framework, this study provides a new and comprehensive view of healthcare accessibility and equity across various hospital tiers using PT and PVs in megacities.

# Thank you!

Yang, Z., Guo, Y., Feng, X., Zhou, Y., Zhou, P., Li, X., & Qian, X. (2024). Evaluating temporal variations in access to multi-tier hospitals using personal vehicles and public transit: Implications for healthcare equity. *Sustainable Cities and Society*, 113, 105687.

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