China Data Institute
Webinar Series on COVID-19 Impact Analysis
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An overview of human mobility and COVID-19 transmission

Mengxi Zhang, mzhang2@bsu.ed
Siqin Wang, s.wang6@uq.edu.au
Tao Hu, taohu@g.harvard.edu
Xiaokang Fu, whistle_ant@whu.edu.cn

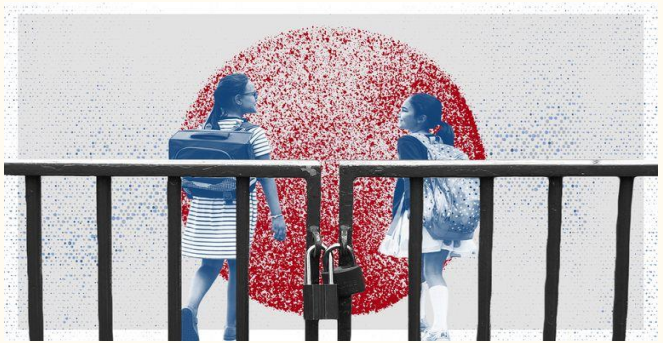
Siqin Wang
Postdoctoral Fellow,
The University of
Queensland, Australia

Tao Hu
Postdoctoral Fellow,
Harvard University,
U.S.

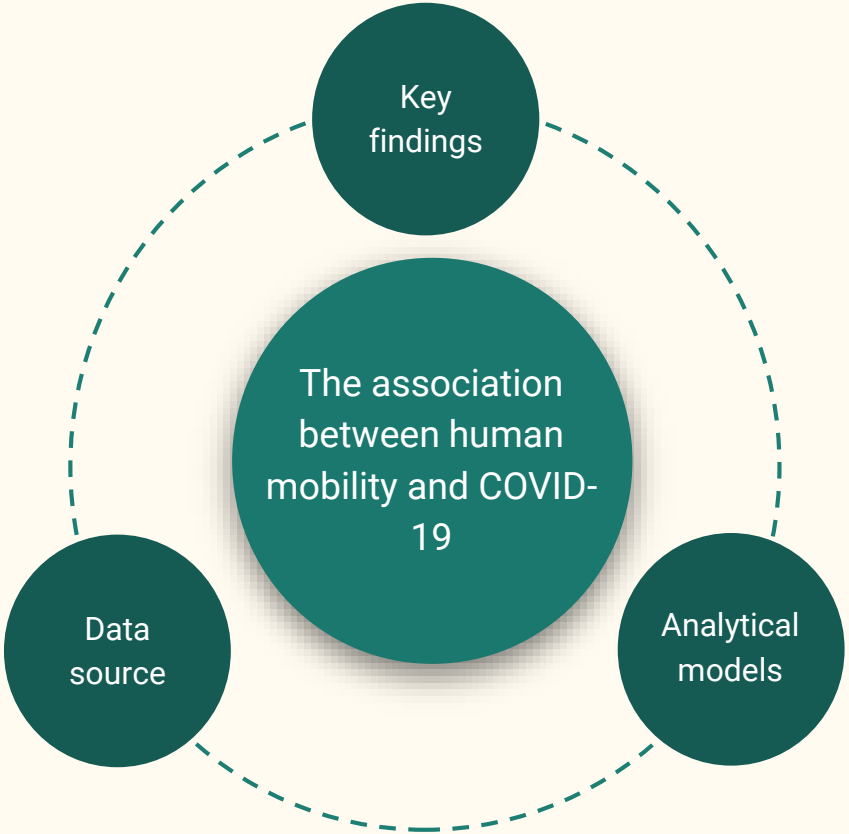
Xiaokang Fu
Postdoctoral Fellow,
Wuhan University,
China

Mengxi Zhang
Assistant Professor,
Ball State University,
U.S.

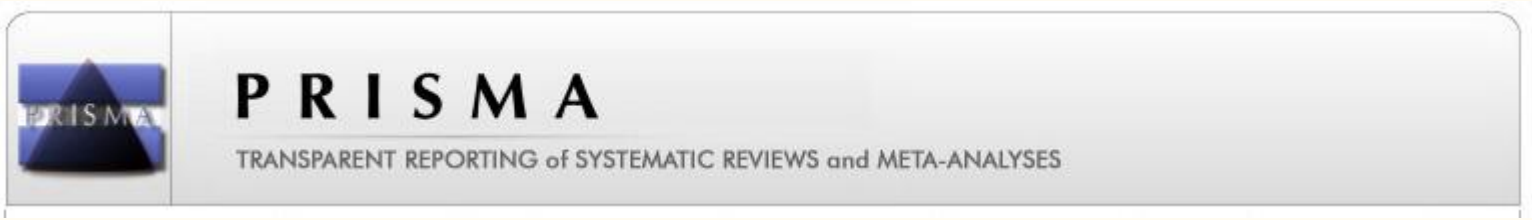
Introduction



Objective


Key findings
The association between human mobility and COVID-19
Data source
Analytical models

Method



Searching timeframe: January 2020 to September 2020

Method

Searching term: ((COVID-19 OR "novel coronaviruses" OR 2019-nCov OR SARS CoV-2) AND ("human mobility" OR "human movement" OR "population flow" OR "social distanc*" OR "physical distanc*" OR "travel restriction" OR "movement control" OR stay-at-home OR lockdown OR shelter-in-place))

Inclusion criteria: 1) measure the association between human mobility and COVID-19 transmission, 2) measure the association between human mobility-related policies and COVID-19 transmission, and 3) apply quantitative methods.

Method

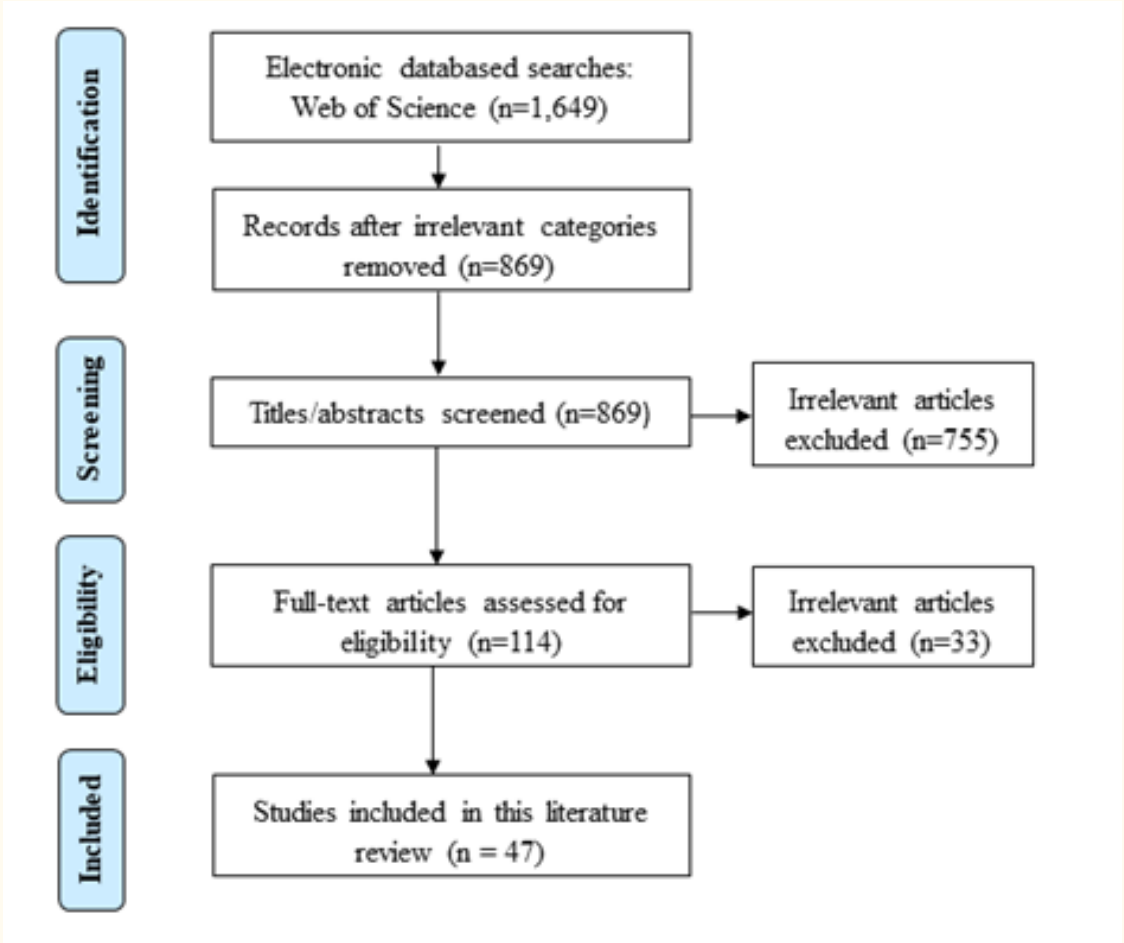


Figure 1. PRISMA flow chart on the identification and screening of studies on human mobility and COVID-19 transmission

Results. Data sources and features

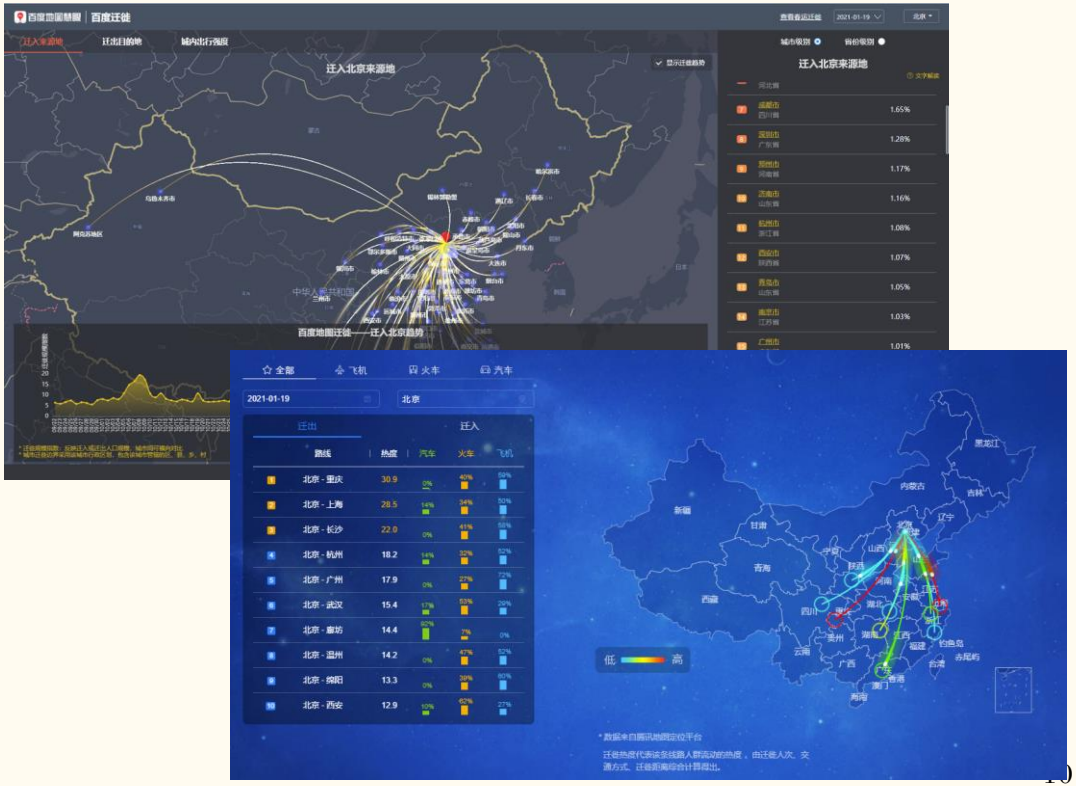
Category	Data Source	Link	Public available	Spatial coverage	Time coverage	Update	Advantages	Disadvantages	References
Big data	Baidu Mobility Index	https://qianxi.baidu.com/	N	City/Province (China)	2020.1.1 ~ 2020.5.8	Daily	Low costs; convenient in data gathering; available in indicating inter-city mobility	Limited region coverage (China mainland); difficult to collect data	[1][71][210][325][676][704][711][752][756][762]
	SafeGraph	https://www.safegraph.com/covid-19-data-consortium	Y	Census Block Group (North America)		Daily	Comprehensive users check-in information with high resolution; reaggregated to any spatial scale, such as census tract, county, and state; estimate human mobilities inter/intro regions	Difficult to process because of large data volume; data is available after applying; it only covers the North American region	[650]
	Google Mobility Report	https://www.google.com/covid19/mobility/	Y	County/State/Country (Global)	2020.1.1 ~ present	Daily	Wide region coverage; convenient in data gathering; low costs	Without inter-region mobility estimation	[722]
	Tencent Mobility Index	https://heat.qq.com/qianxi.php	N	city (China)	Daily	Daily	Real-time updates;	Difficult to collect data; only available at city level	[750]
Public Transit	Airline Flight	N/A	N	County/State/Country(Global)			Convenient in data gathering; wide region coverage	Partially covering global flight information; only available in historical data; not publicly available	[22][137]
Census		N/A	Y	County/State/Country	Yearly	Yearly	Low Costs; Convenient Data Gathering; Precise Results	Low update frequency;	[749]
Survey		N/A	N		2019	N/A	1. High Representativeness 2. Low Costs 3. Convenient Data Gathering 4. Precise Results	Low update frequency	[722] [733]

Public Transit, Census, and Survey

- Public Transit
  - Air Flight
    - Bureau of Transportation Statistics: including passengers stats. but historical data
    - International Air Transport Association (IATA) : comprehensive but not free
    - OpenSky: monthly update and free to download but without passengers info
- Census
  - Migration/Geographic Mobility: yearly-based historical data
- Survey
  - Accurate and verifiable data based on survey questions
  - Sample data and time consuming for large research area

Data sources: Baidu and Tencent Mobility Index

- Baidu Mobility Index
  - Inflow/outflow mobility index
  - Inflow/outflow mobility intensity
  - Intra-city mobility intensity
- Tencent Mobility Index
  - Top-10 inflow/outflow mobility index inter-cities

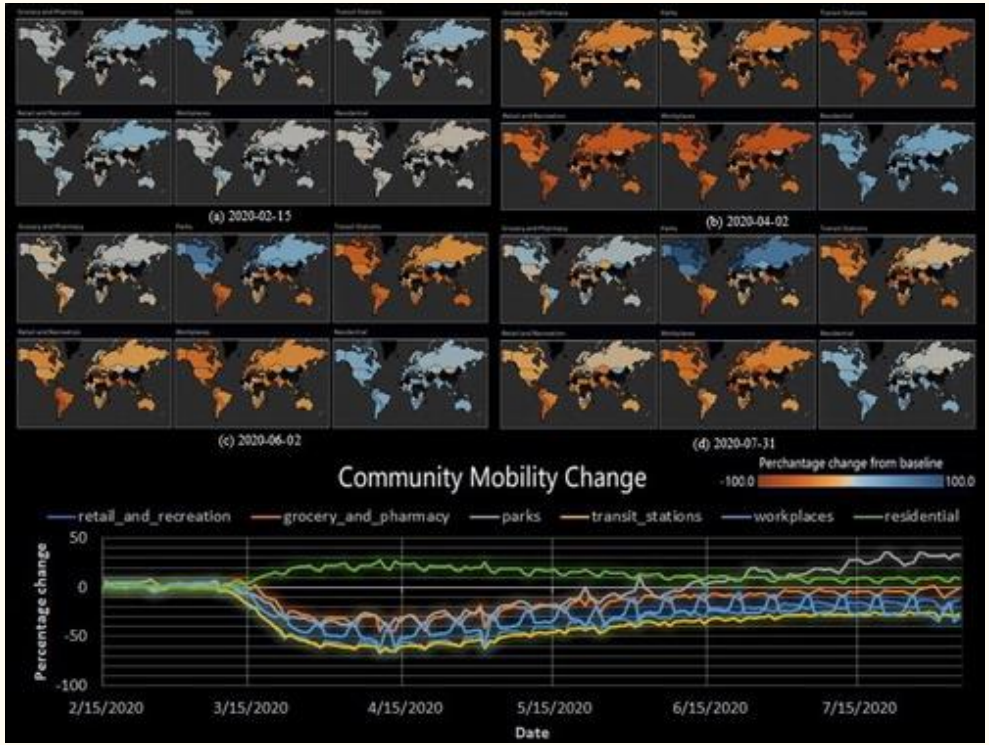


- **Pros**: comprehensive mobility-related indicators
- **Cons**: data collection with crawler; uncertain availability; China only

Data sources: Google Mobility Report

The reports chart movement trends over time by geography, across different categories of places such as **retail and recreation**, **groceries and pharmacies**, **parks**, **transit stations**, **workplaces**, and **residential.**

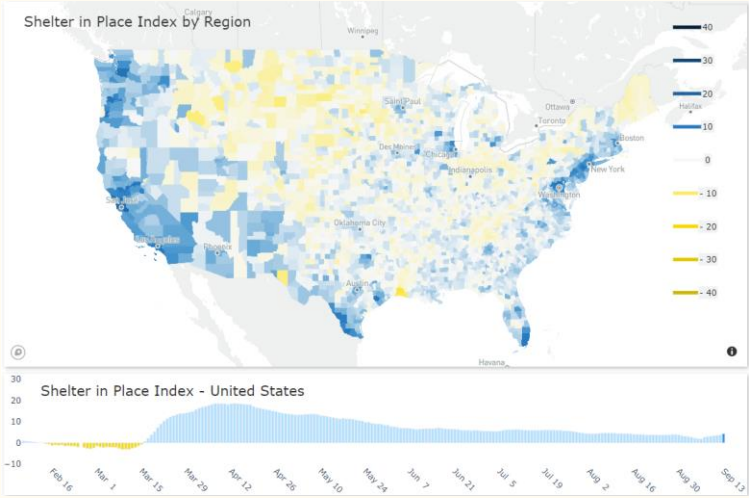
- Most countries
- Country/State/County
- 1/1/2020 ~ present
- CSV file
- Without inter-region mobility index

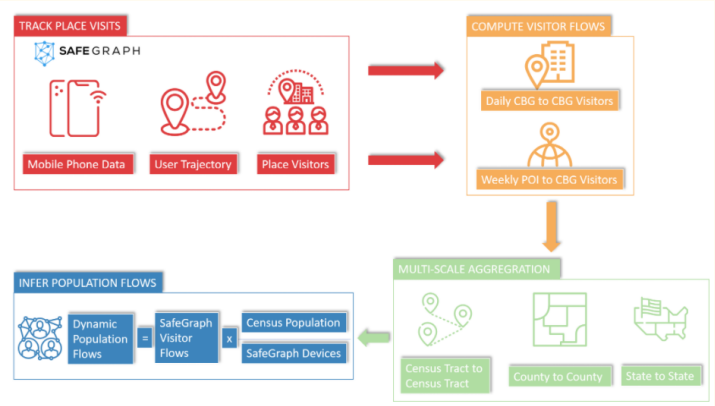


Yang, C., Sha, D., Liu, Q., Li, Y., Lan, H., Guan, W. W., ... & Ding, A. (2020). Taking the pulse of COVID-19: A spatiotemporal perspective. *International journal of digital earth*, *13*(10), 1186-1211.

Data sources: SafeGraphs

- The POI access in SafeGraph data is categorized by industry and business (e.g., grocery stores, bars, hotels), by brand (e.g., Costco, Walmart), by regions, et al.
- Derived mobility index
  - GeoDS Lab, Department of Geography, University of Wisconsin-Madison
  - Geoinformation and Big Data Research Laboratory (GIBD), Department of Geography, University of South Carolina





https://geods.geography.wisc.edu/

http://gis.cas.sc.edu/gibd/covid-19/

Results. Analytical models

- Mathematical models are very important for the prediction, analysis and control of the spread of epidemics.
- According to different classification standards, the mathematical models used in epidemics can be divided into different categories.
- Based on the work of (Siettos and Russo 2013), we divide the mathematical models used in reviewed articles into three categories according to the characteristics of models

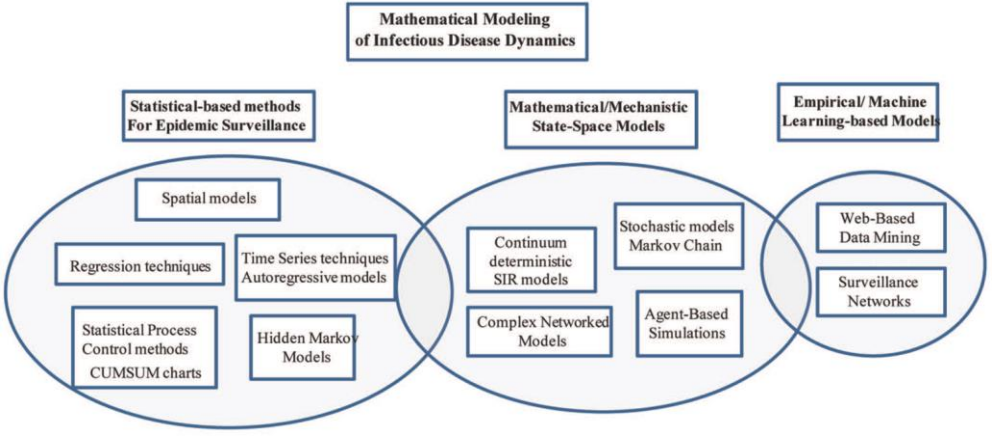


Figure 1. An overview of mathematical models for infectious diseases.

Siettos, C ia Russo. 2013. "Mathematical Modeling of Infectious Disease Dynamics." *Virulence* 4 (4): 295–306. https://doi.org/10.4161/viru.24041.

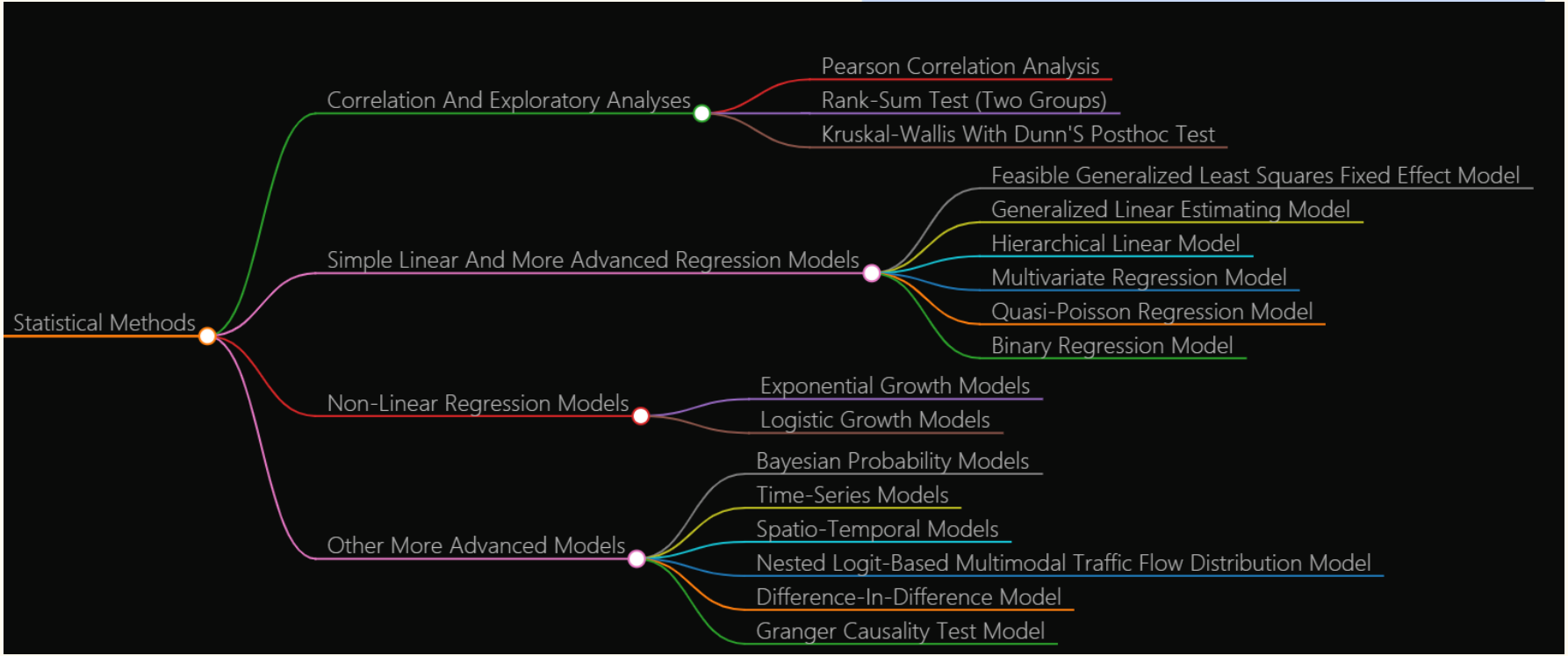
Results. Analytical models

The mathematical models for the analysis, simulation, and prediction of the spread of COVID-19 by involving human mobility as key variables or parameters.

- **Statistical methods(26 studies)**
  - Correlation and exploratory analyses
  - Simple linear and more advanced regression models
  - Non-linear regression models
  - Other more advanced models
- **Mathematical/mechanistic state-space models(or called dynamic system models, 21 studies)**
  - Susceptible-Infectious-Recovered (SIR) & Susceptible-Exposed-Infectious-Recovered (SEIR) models
  - The extended or modified SIR or SEIR models
  - Combined models integrating the classic SIR or SEIR models with other statistical models
- **Simplified arithmetic models(1 study)**

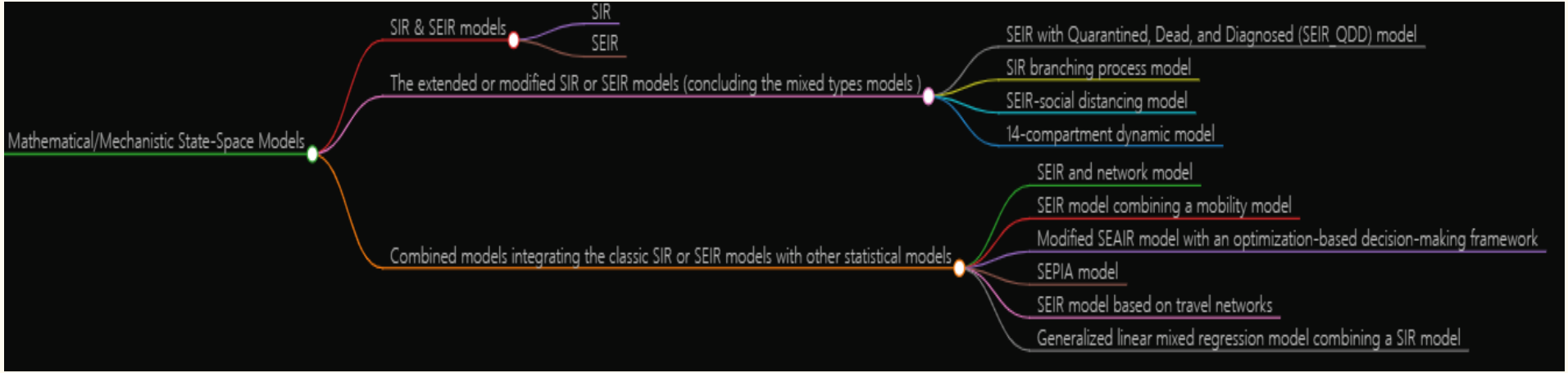
Results. Analytical models

Statistical methods



Results. Analytical models

Mathematical/Mechanistic State-Space Models



Results. Analytical models

Simplified Arithmetic Models

- It uses only very simple calculations (only use addition, subtraction, multiplication, division, rounding off, a few conditional statements, and two unavoidable power terms) to ensure the interpretability of the model.

- This model create for non-specialist readers to understand the process of modeling and in-depth inspect numerical predictions.

Results. Study purpose

1) **Policy implementation and evaluation**: examining the effect of policy-induced mobility control on COVID-19

2) **Simulation and prediction:** predicting the COVID-19 dynamic through modeling or simulating human mobility or its related measures

3) **Cross-country/region comparison:** conducting comparative studies presenting the association between human mobility and COVID-19 across countries or regions

Results. Key findings

Policy implementation and evaluation

1) Policy interventions including lockdown, travel restrictions, social distancing, and border control have effectively reduced the transmission of COVID-19, although the timing, effectiveness, and stringency of policy implementation matter.
2) The earlier the social restriction implemented, the better and more effective result on lowering the peak value of new infections and reducing the infection scale
3) The mobility-spread relationship is temporal and spatial heterogeneity.
4) Policy measures need to be adjusted across the different phases of the pandemic.
5) Mobility control is observed to have a time-lag effect on the virus transmission and such effect varies across the geographic contexts and the timeline of the pandemic

Results. Key findings

Simulation and prediction

The modeling work conducted in our selected papers provides similar findings regarding the policy implementation and mobility control as described in the previous section, besides:

1) Policy interventions parameterized in the modeling process should be adjustable, allowing the evaluation of local policy scenarios and relaxing political measures
2) Developing multi-disciplinary models should be able to explore temporal changes in spreading patterns and outbreak dynamics and estimate the potentials of vaccination
3) Some models have the capability to predict the outbreak spreading and the pandemic cessation dates

Results. Key findings

Cross-country/region comparison

1) Policy interventions may well explain the majority of cross-country variation in virus control in the initial pandemic stage.
2) However, these are less definitive conclusions if extend to a full spectrum of the pandemic.
3) When it comes to implementing different policy approaches to the pandemic, careful consideration of cross-country differences is required in terms of countries' nature and their demographic and socioeconomic variations.

Discussion

1) **Encouragement of multidisciplinary studies**

2) **Adjustment of policies**

3) **Methodological improvement**

4) **Enrichment of data sources**

Discussion

1) **Encouragement of multidisciplinary studies**

   Extending to second/third epidemic, the measurement of covert cases

   Extend to border controls at a regional or national level and testing and tracing policies at an individual level

   Extend to include the effect of seasonality on the transmission

   Extend the mobility tracing of humans to animals to seek for virus origins

Discussion

2） Adjustment of policies

Policy interventions have been gradually upgraded along the timeline of the pandemic

Evaluations about the effectiveness of intermediate measures to control the social and economic cost

Need to include other factors in prevention and control measures, such as case detection with testing and isolation, contact tracing and quarantining, the quality and preparedness of the healthcare system, and population and housing density

Great caution is needed as gradual, exploratory steps toward re-opening

Appropriate education about the virus risk is necessary

Discussion

3） Methodological improvement

Need to improve model accuracy by involving further COVID-19 data, such as extending the confirmed cases to asymptomatic cases, considering the time gap with the confirmed COVID-19 cases

Model parameters can involve the measures of the effectiveness of policy implementation and pharmaceutical factors

Individual-level models need to include many patient-specific factors, including demographic and socioeconomic status

Aggregated-level models can extend to consider area-specific factors to distinguish heterogeneity within the regions

Further research can be carried out in unifying temporary and spatial dimensions by distinguishing the different stages of pandemic

Discussion

4） Enrichment of data sources

Involve additional data, to use a combination of multi-sourced data, and to compare the reliability and quality of data, e.g. user-based social media big data (e.g., geotagged Twitter data) is able to indicate the inter-regional movement to improve the accuracy of models

Data sharing and information disclosure are encouraged for future studies.

Limitation

Did not include non-peer-reviewed articles

Restricted searching timeframe from January 2020-September 2020

- Obtained limited articles covering the second and third waves of the COVID-19 pandemic
- Included limited articles focusing on African and South America

Conclusion

The importance of prompt and sustainable measures.

The needed of the multidisciplinary collaborations.

Acknowledgement. Human Mobility Group

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Haokun Liu, University of Bern, Switzerland

Zhimin Liu, East China Normal University, China

Collaboration to be continued

1. Mengxi Zhang et al. Human mobility and COVID-19 transmission: a systematic review and future directions
2. Siqin Wang et al. A bibliometric analysis and network visualisation of human mobility studies from 1990 to 2020: emerging trends and future research directions.
3. Tao Hu et al. Mobility Data in COVID-19 Pandemic: Applications and Challenges

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