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China Data Institute

Center for Geographic Analysis
Harvard University

社会地理计算联合研究中心
Geocomputation Center for Social Science

Using Google Community Mobility Reports in COVID-19 Research

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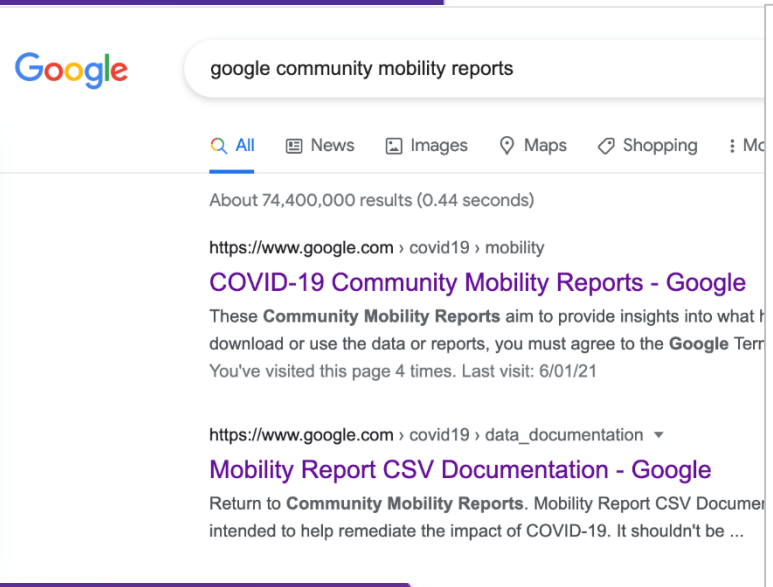
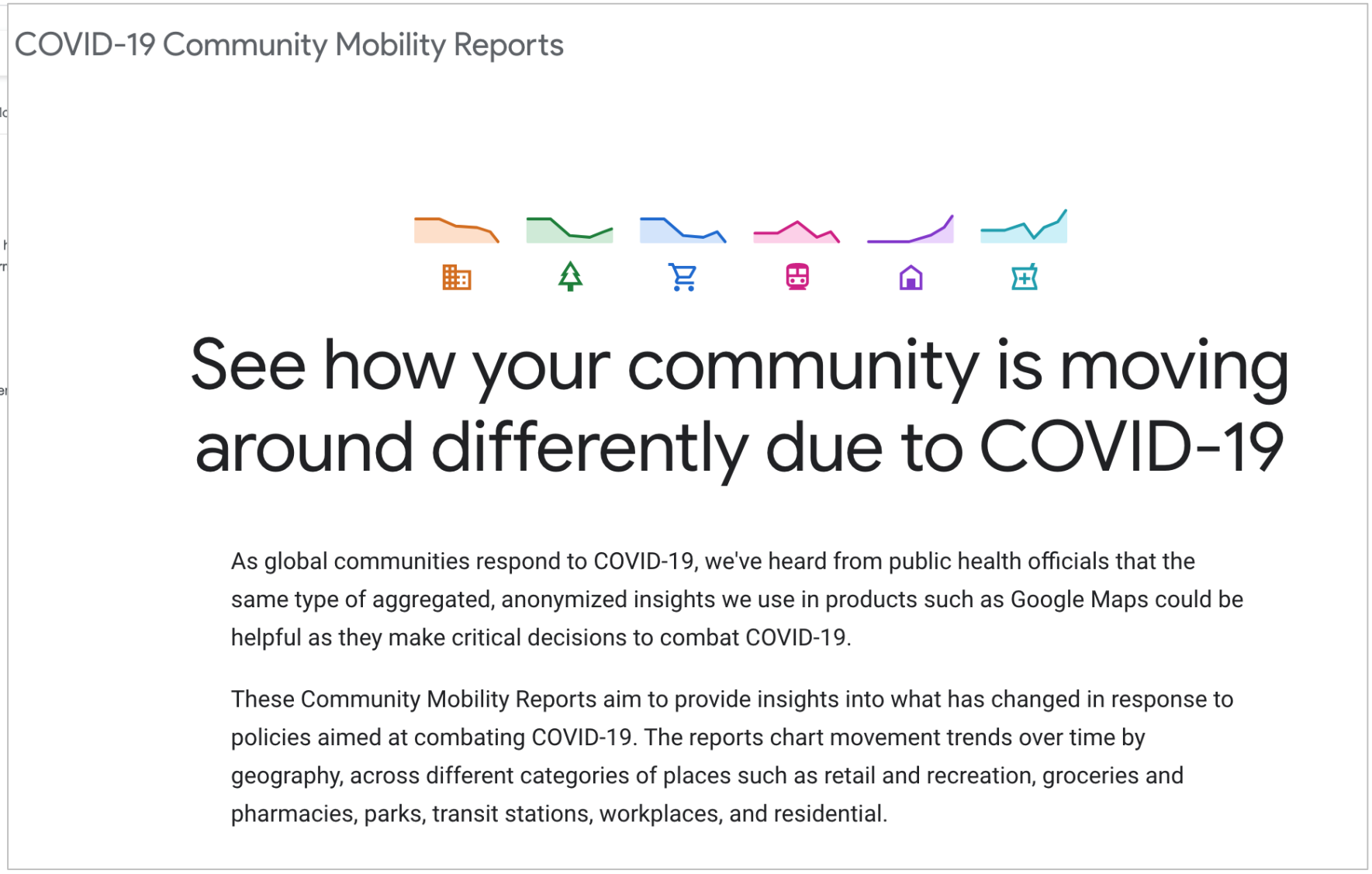
Outline

- How to obtain Google Community Mobility Reports (Google CMR)?
- How Google CMR are derived?
- What information do Google CMR contain?
- What is the specialty of Google CMR?
- How to use Google CMR in COVID-19 studies?

How to obtain Google Community Mobility Reports?

https://www.google.com/covid19/mobility/





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How to obtain Google Community Mobility Reports?

Community Mobility Reports

Reports created 2021-05-10.
In order to download or use the data or reports, you must agree to the Google Terms of Service.

Global CSV as a whole

Regional CSV respectively

Global CSV | Region CSVs

CSV documentation | How to use these reports

Search by country or region

Afghanistan	EN	Download PDF
Angola	EN	Download PDF
Antigua and Barbuda	EN	Download PDF
Argentina Regions	EN	Download PDF
Aruba	EN	Download PDF
Australia Regions	EN	Download PDF

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How Google CMR are derived?

Raw data: use Google Maps to detect the changes of mobility using the aggregated and anonymized user data showing the popular times for places (six types) in Google Maps.

Measures: how visits and length of stay at different places change compared to a baseline for that day of the week — the baseline is the median value of mobility during the 5-week period Jan 3–Feb 6, 2020.

Potential bias: the datasets show trends over several months with the most recent data representing approximately 2-3 days ago—this is how long it takes to produce the datasets.

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How Google CMR are derived?

Six types of places

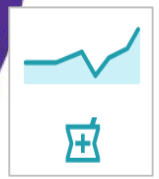
Grocery & pharmacy (grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies)

Parks (local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens)

Transit stations (public transport hubs such as subway, bus, and train stations)

Retail & recreation (restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters)

Residential (places of residence)



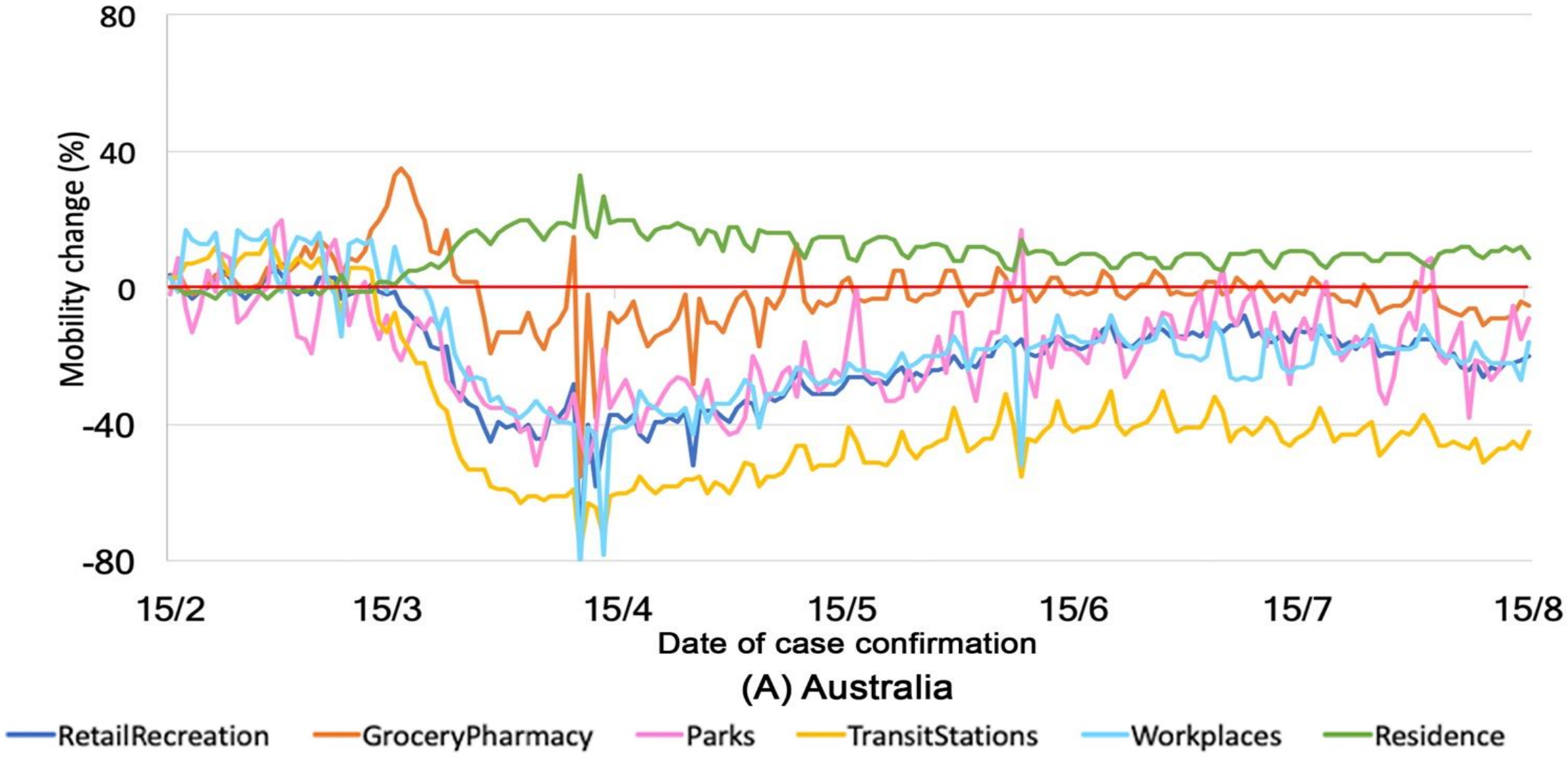
Workplaces (places of work)

How Google CMR are derived?

Example: how a public holiday/weekend can affect people's travel behavior

How Google CMR are derived?

‘Weird’ weekly pattern



How does Google CMR look like?

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
country_regi	country_regi	sub_region_1	sub_region_2	metro_area	iso_3166_2_	census_fips_	date	retail_and_recreation_	grocery_and_pharmac	parks_percent_change	transit_stations_	workplaces_p	residential_percent_	
AE	United Arab Emirates						15/2/20	0	4	5	0	2	1	
AE	United Arab Emirates						16/2/20	1	4	4	1	2	1	
AE	United Arab Emirates						17/2/20	-1	1	5	1	2	1	
AE	United Arab Emirates						18/2/20	-2	1	5	0	2	1	
AE	United Arab Emirates						19/2/20	-2	0	4	-1	2	1	
AE	United Arab Emirates						20/2/20	-2	1	6	1	1	1	
AE	United Arab Emirates						21/2/20	-3	2	6	0	-1	1	
AE	United Arab Emirates						22/2/20	-2	2	4	-2	3	1	
AE	United Arab Emirates						23/2/20	-1	3	3	-1	4	1	
AE	United Arab Emirates						24/2/20	-3	0	5	-1	3	1	
AE	United Arab Emirates						25/2/20	-3	2	3	-2	3	1	
AE	United Arab Emirates						26/2/20	-2	1	-3	-2	3	1	
AE	United Arab Emirates						27/2/20	1	5	-1	-1	3	1	
AE	United Arab Emirates						28/2/20	1	5	-1	-1	1	1	
AE	United Arab Emirates						29/2/20	2	7	-1	-1	5	0	
AE	United Arab Emirates						1/3/20	3	10	2	-1	4	1	
AE	United Arab Emirates						2/3/20	0	7	1	-2	4	1	
AE	United Arab Emirates						3/3/20	0	6	0	-5	4	1	
AE	United Arab Emirates						4/3/20	-1	7	-2	-5	3	2	
AE	United Arab Emirates						5/3/20	-3	6	-2	-5	3	2	
AE	United Arab Emirates						6/3/20	-7	5	-8	-9	0	3	
AE	United Arab Emirates						7/3/20	-3	6	1	-8	4	2	
AE	United Arab Emirates						8/3/20	1	8	6	-9	-1	3	
AE	United Arab Emirates						9/3/20	-3	4	4	-10	-1	4	
AE	United Arab Emirates						10/3/20	-4	6	3	-11	-2	4	
AE	United Arab Emirates						11/3/20	-4	5	0	-12	-2	4	
AE	United Arab Emirates						12/3/20	-8	6	-6	-15	-3	5	
AE	United Arab Emirates						13/3/20	-16	3	-15	-20	-2	5	
AE	United Arab Emirates						14/3/20	-12	4	-12	-17	2	4	
AE	United Arab Emirates						15/3/20	-6	11	-11	-15	-4	5	
AE	United Arab Emirates						16/3/20	-11	8	-14	-17	-6	6	
AE	United Arab Emirates									-18	-22	-9	7	
AE	United Arab Emirates									-19	-25	-11	9	

What is the specialty of Google CMR?

Preprint version:
https://www.researchgate.net/profile/Tao-Hu-11/publication/349537730_Human_Mobility_Data_in_the_COVID-19_Pandemic_Characteristics_Applications_and_Challenges/links/6035a0a4a6fdcc37a8496da2/Human-Mobility-Data-in-the-COVID-19-Pandemic-Characteristics-Applications-and-Challenges.pdf

Human Mobility Data in the COVID-19 Pandemic: Characteristics, Applications, and Challenges

Tao Hu[1], Siqin Wang[2,*], Bing She[3], Mengxi Zhang[4], Xiao Huang[5,*], Yunhe Cui[6], Jacob Khuri[7], Yaxin Hu[8], Xiaokang Fu[9], Xiaoyue Wang[9], Peixiao Wang[9], Xinyan Zhu[9], Weihe Wendy Guan[1], Shuming Bao[10], Zhenlong Li[11]

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Features of four types of mobility data:

1.Public transit system data;
2.Social activity; --- Google CMR
3.Index-based mobility data;
4.Social media-derived mobility data

Data Category		Name and Provider	Region and scale	Available Time	OD Flow	Availability	Strengths	Weaknesses	Selected References
Public Transit System	Air flight	International Air Transport Association (IATA)	Worldwide	Since 2010	Yes	Private	Rich information for business intelligence. Aggregated statistics for various applications	Mostly private data	Menkir et al., 2021 Bogoch et al., 2020
		OpenSky-Network	Worldwide, mostly for Europe and North America	Since 2012	Yes	Public	Detailed tracking information	API limitations	Zhuang et al., 2020 Iacus et al., 2020
	Train	Transit system / dataset in different countries (e.g., China, U.S., Italy)	China, USA, Italy (by state, city, district)	Different for different regions	Yes	Public	Available in countries where there is a booking website	Real-time data but without history data o sometimes web crawling needed	Zhang et al.,2020; Carteni et al., 2020 Hu et al., 2020
	Metro	Transport authority (e.g., MATSim-NYC)	U.S.	Different for different regions	No	Public	Detailed ridership data, at the station level	Non-trackable; no route record	Zheng et al.,2020; Ahangari et al., 2020
Social Activity		Apple Mobility Trends Report	Worldwide/city, county, state	04/14/2020 ~ present	No	Public	global wide; one single file; data divided by country/region, sub-region, city	data source method (requests for direction in Apple Maps)	Huang et al., 2020b Kurita et al., 2021; Hadjidemetriou et al., 2020
		Google Mobility Reports	Worldwide/city, county, state	2/15/2020 ~ present	No	Public	global wide; one single file	not comparable among countries	Pepe et al.,2020; Delen et al., 2020; Rutz et al., 2020
		Foursquare Mobility Reports	U.S./county, state	02/19/202 ~present.	No	Submit Application	Available in 25 types of POI and by age group	Only available in U.S	Gao et al., 2020 Fathi-Kazerooni et al.,2020 Ding et al.,2020
		SafeGraph Mobility Reports	U.S./census tract, county, and state	01/01/2019 ~present	Yes	Submit Application	Varieties of data categories	Data are only availabl on Amazon S3	Li et al., 2020 Kang et al. 2020
Index-based Mobility Data		Cuebiq Mobility Index	U.S. at multiple geographic levels	01/01/2020	No	Submit Application	Available in DMA level; index allows counties to be compared to one another	Only available in U.S.	Fraiberger et al., 2020 Pepe et al., 2020
		Baidu Mobility Index	China/city and province	1/1/2020 ~ 5/7/2020 & 9/3/2020 ~ presen	Yes	Public	inter/intro-city mobility index	Not publicly accessible after May 7 2020, only available for Mainland China	Ze-Liang et al., 2020 Liu et al., 2020 Xu et al., 2020
		Descartes Lab Mobility Index	U.S./county and state	03/01/2020 – 06/06/2020	No	Submit Application	accurate positioning data (m50 score based on normalization methods)	Inter-city index not covered; only freely available in a certain period of time and scale	Warren et al., 2020 Gao et al., 2020; Chen et al., 2020
		Unacast Social Distancing Index	U.S.	02/24/2020 ~ present	No	Submit Application	Granular data, available down to specific data points; bias correction based on classifications of businesses	Since data is coming from third party sources, people may have to agree to consent on those sources	Brodeur et al., 2021
		University of Maryland Mobility Metrics and Social Distancing Index	U.S./county and state	01/01/2020 ~ present	No	Submit Application	Integrated and cleaned location data from multiple sources; be highly representative	Only available in the U.S.	Zhang et al., 2020 Lee et al., 2020 Ghader, et al., 2020
		Camber Systems Social Distancing Reporter	U.S./county	08/01/2020 ~ present	No	Submit Application	Integrating multiple data sources; less biased and more representative; easy to interpret	subject to calibration; only available in U.S. county level; no data before August 2020	Jeffrey et al., 2020
Social Media-Derived Mobility Data		Geotagged Tweets	Worldwide/any spatiotemporal scale	01/01/2018 ~ present	Yes	Public	Worldwide coverage, real-time, aggregation-flexible	Bias in population, low penetration	Huang et al., 2020a Li et al., 2021 Su et al., 2020
		Facebook Movement Range Maps	Worldwide	01/03/2020 ~ 31/08/2020	No	Submit Application	Machine-readable format that is global and free of charge	Only provided by mobile phone users who have enabled location history	Lau et al.,2020; Kuchler et al., 2020 Beria et al., 2021

What is the specialty of Google CMR?

Comparison across other types of society activity data

Data Category	Name and Provider	Region and scale	Available Time	OD Flow	Availability	Strengths	Weaknesses	Selected References
Social Activity	Apple Mobility Trends Report	Worldwide/city, county, state	04/14/2020 ~ present	No	Public	global wide; one single file; data divided by country/region, sub-region, city	data source method (requests for direction in Apple Maps)	Huang et al., 2020b Kurita et al., 2021; Hadjidemetriou et al., 2020
	Google Mobility Reports	Worldwide/city, county, state	2/15/2020 ~ present	No	Public	global wide; one single file	not comparable among countries	Pepe et al.,2020; Delen et al., 2020; Rutz et al., 2020
	Foursquare Mobility Reports	U.S./county, state	02/19/202 ~present.	No	Submit Application	Available in 25 types of POI and by age group	Only available in U.S	Gao et al., 2020 Fathi-Kazerooni et al.,2020 Ding et al.,2020
	SafeGraph Mobility Reports	U.S./census tract, county, and state	01/01/2019 ~present	Yes	Submit Application	Varieties of data categories	Data are only availabl on Amazon S3	Li et al., 2020 Kang et al. 2020

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What is the specialty of Google CMR?

Advantages:

Global scale (including 133 countries)

Some countries have a finer level data (e.g. State/City)

Long temporal coverage (Feb 15, 2020 to present)

Publicly available (easy to download and process)

Disadvantages:

Data representativeness (subject to Google Users)

Less comparable across countries

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How to use Google CMR in COVID-19 studies?
---- Review paper on COVID-19 and human mobility

https://www.medrxiv.org/content/10.1101/2021.02.02.21250889v1.full.pdf

Human mobility and COVID-19 transmission: a systematic review and future directions

Mengxi Zhang, Siqin Wang, Tao Hu, Xiaokang Fu, Xiaoyue Wang, Yaxin Hu, Briana Halloran, Yunhe Cui, Haokun Liu, Zhimin Liu, Shuming Bao

doi: https://doi.org/10.1101/2021.02.02.21250889

Abstract

Without a widely distributed vaccine, controlling human mobility has been identified and promoted as the primary strategy to mitigate the transmission of COVID-19. Many studies have reported the relationship between human mobility and COVID-19 transmission by utilizing the spatial-temporal information of mobility data from various sources. To better understand the role of human mobility in the pandemic, we

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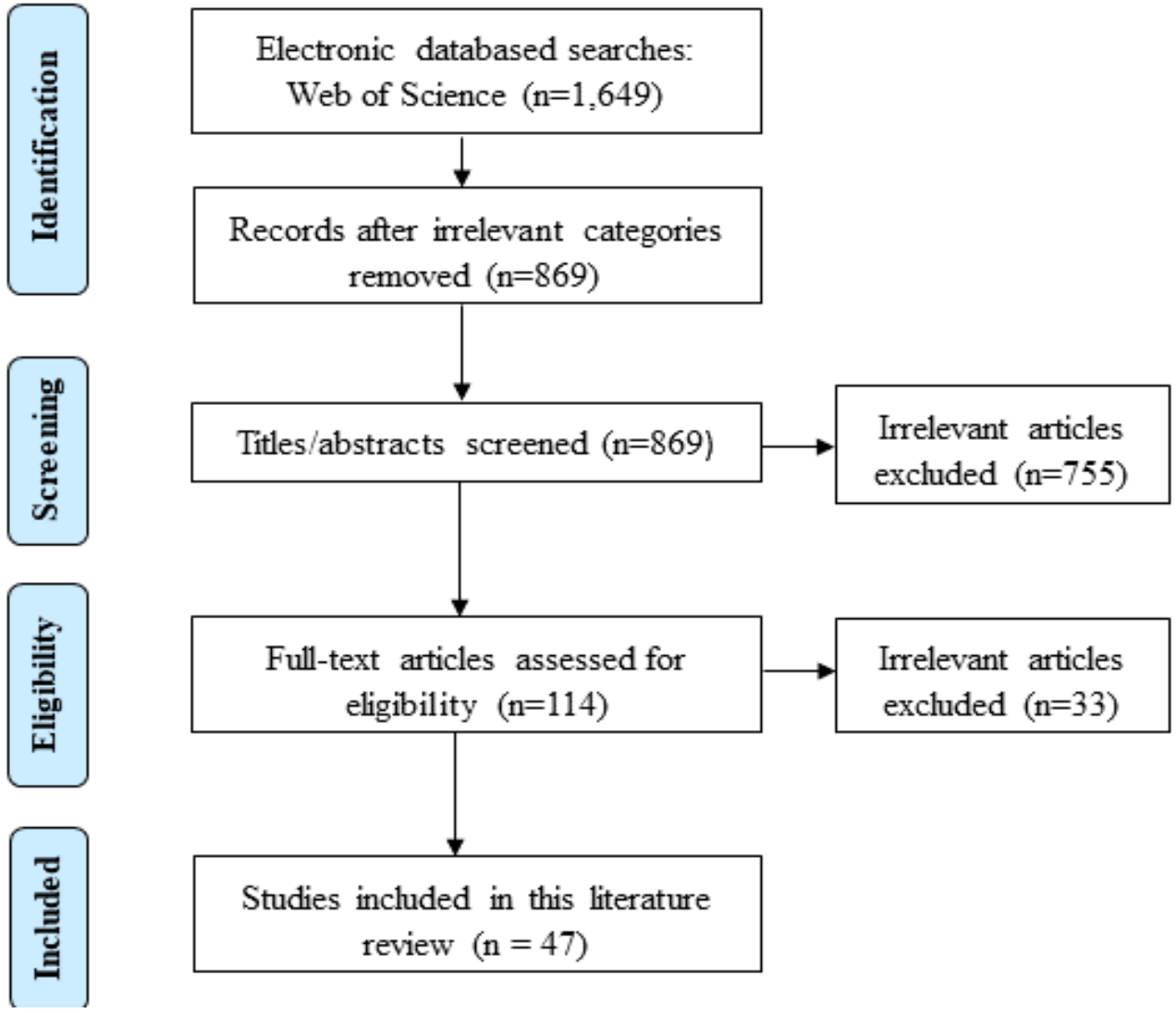
---- Review paper on COVID-19 and human mobility

PRISMA flow chart on the identification and screening of studies on human mobility and COVID-19

Method: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Searching database: Web of Sciences (covering published articles)

Searching terms: "((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))".



How to use Google CMR in COVID-19 studies?
---- Review paper on COVID-19 and human mobility

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	[22][137]
								in historical data; not publicly available	
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]

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How to use Google CMR in COVID-19 studies?
---- Review paper on COVID-19 and human mobility

Second-round search:

Database: Google Scholar (covering preprints, working papers, etc)

Searching selection: by high relevance and citations larger than 10

Searching results: 50+ papers highly relevant

Case studies using Google CMR in below countries:

Australia, United States, South Korea, Sweden, Italy, France, Spain, and 23 European countries; 100 countries comparison

Authors/Title	Data used	Method	Application
Pepe et al.	Google Community Mobility Dataset; Apple mobility Trends Report; Cuebiq data for Good	Python 3; Pearson's correlation coefficient	A dataset to assess mobility changes in Italy following national lockdown: It presents daily time-series of three different aggregated mobility metrics by using cuebiq data:——the origin-destination movements between Italian provinces, the radius of gyration, and the average degree of a spatial proximity network,
Rutz et al.	801 publicly visible animal tracking studies from the move bank research platform ; Google Community Mobility Dataset	QGIS	To quantify the effects of human activity on wildlife: Using google community mobility data (local parks, national parks, public beaches, marinas, dog parks, plazas and public gardens)
Wellenius et al.	Google Community Mobility Dataset		Conclusion: state-wide mandates are effective in promoting social distancing within this study group.
Delen et al.	GPS mobility data from Google、Apple ; disease statistics from the European Centre for Disease Prevention and Control	machine learning、Gradient boosted trees regression analysis	Conclusion: Consistent with simulation-based studies, real cross-national transactional data confirms the effectiveness of social distancing interventions in slowing the spread of COVID-19
Morita et al.	Google Community Mobility Dataset ; Stringency Index Cases and death; Democracy Index	generalized linear mixed model	The study shows that the status of the infection spread and policy implementation uniformly influence behavior restrictions across every country. Furthermore, it suggests that the differences in the key contents of the social distancing policies and the socioeconomic status of each country may influence the ratio of behavior changes.
Vokó et al.	Google Community Mobility Dataset ; ECDC data	Poisson regression; interrupted time series analysis; multivariate regression analysis	Conclusion : The unprecedented "stay-at-home" national policies meaningfully contributed to the suppression of the COVID-19 pandemic in Europe
Klonowska and Bindt et al.	Google Community Mobility Dataset ; Austria stay-at home data		Two waves of technological responses in the European Union: 1. anonymized phone location tracking 2. contact tracing apps Both waves of technological solutions are discussed in terms of privacy, transparency, and effectiveness.
Juranek et al.	Google Community: Mobility Dataset ; regional weekly numbers (statistic Denmark)	regression model	This paper studies the labor market effects of non-pharmaceutical interventions (NPIs) to combat the COVID-19 pandemic
Bucsky	transport automatic measured data (Budapest Roads Ltd) ; Google Community Mobility Dataset ; bike sharing system (BSS) usage data (BKK) ;	Compared to last year	To analyze the changes made to patterns of transport by movement restrictions (Measurement of time spent outside home and workplace was taken from Google.)
Dasgupta et al.	Mobile device location data ; Google Community Mobility Dataset	Negative binomial regression	Conclusion: We found that the adoption of social distancing practices was strongly correlated with better community health and financial resources. Our findings also suggest the need to innovate additional measures to prevent viral transmission in places where social distancing is less feasible.

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How to use Google CMR in COVID-19 studies?
---- Review paper on COVID-19 and human mobility

Key findings in terms of research aims:

1) Policy implementation and evaluation: examine the effectiveness of policy-induced mobility control on COVID-19
2) Simulation and prediction: predict the COVID-19 dynamic through modeling or simulating human mobility or its related measures
3) Cross-country/region comparison: compare studies presenting the association between human mobility and COVID-19 across countries or regions

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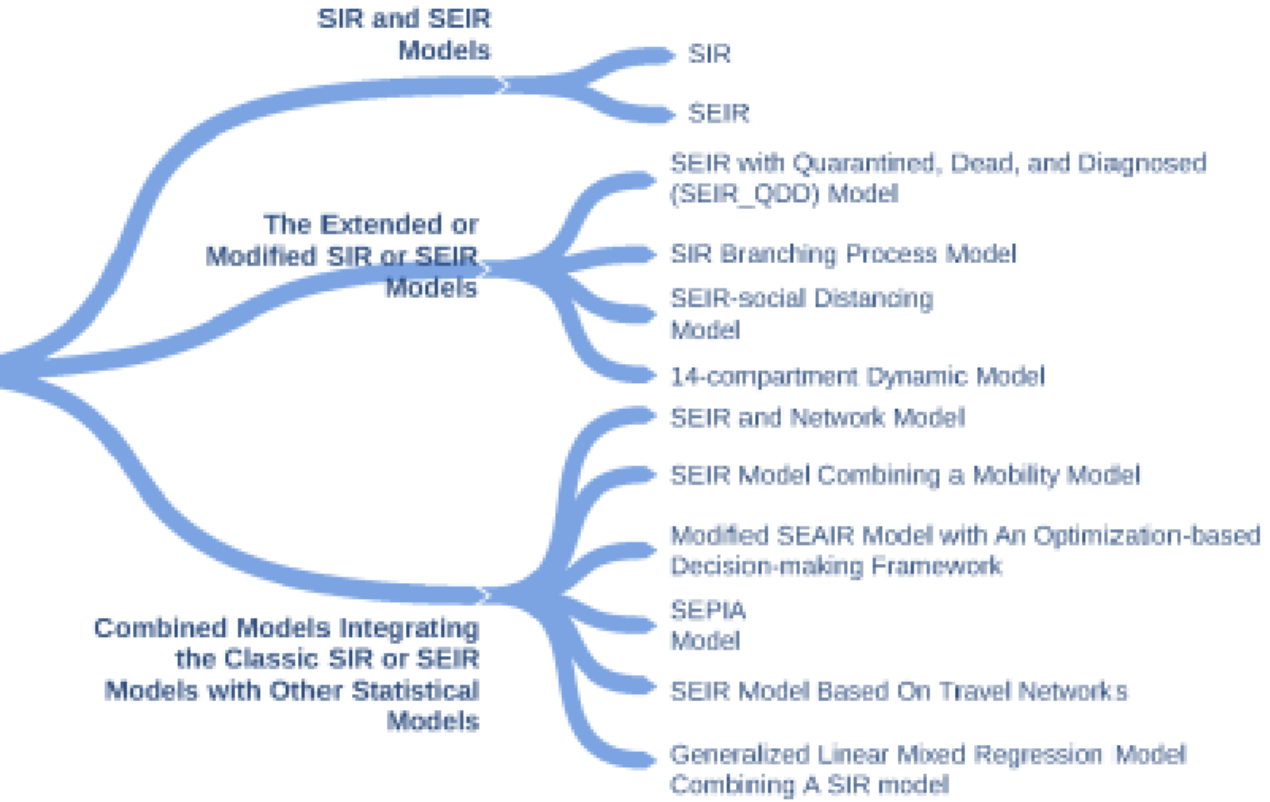
How to use Google CMR in COVID-19 studies?
---- Review paper on COVID-19 and human mobility

Key findings in terms of research outcomes:

1) Policy implementation and evaluation: ‘effective’, ‘time-lag effects’, ‘the earlier implemented the better’, ‘policy adherence and stringency’.



2) Simulation and prediction: SIR/SEIR/ASIR and other mode

3) Cross-country/region comparison: international experiences

How to use Google CMR in COVID-19 studies?
---- Case Study in Australia

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Examining the Change of Human Mobility Adherent to Social Restriction Policies and Its Effect on COVID-19 Cases in Australia

https://doi.org/10.3390/ijerph17217930

International Journal of *Environmental Research and Public Health*

Article

Examining the Change of Human Mobility Adherent to Social Restriction Policies and Its Effect on COVID-19 Cases in Australia

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[2] Center for Geographic Analysis, Harvard University, Cambridge, MA 02138, USA; taohu@g.harvard.edu
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Abstract: The policy induced decline of human mobility has been recognised as effective in controlling the spread of COVID-19, especially in the initial stage of the outbreak, although the relationship among mobility, policy implementation, and virus spread remains contentious. Coupling the data of confirmed COVID-19 cases with the Google mobility data in Australia, we present a state-level empirical study to: (1) inspect the temporal variation of the COVID-19 spread and the change of human mobility adherent to social restriction policies; (2) examine the extent to which different types of mobility are associated with the COVID-19 spread in eight Australian states/territories; and (3) analyse the time lag effect of mobility restriction on the COVID-19 spread. We find that social restriction policies implemented in the early stage of the pandemic controlled the COVID-19 spread effectively; the restriction of human mobility has a time lag effect on the growth rates of COVID-19, and the strength of the mobility-spread correlation increases up to seven days after policy implementation but decreases afterwards. The association between human mobility and COVID-19 spread varies across space and time and is subject to the types of mobility. Thus, it is important for government to consider the degree to which lockdown conditions can be eased by accounting for this dynamic mobility-spread relationship.

Keywords: human mobility; COVID-19 spread; global pandemic; social restriction policy; Australia

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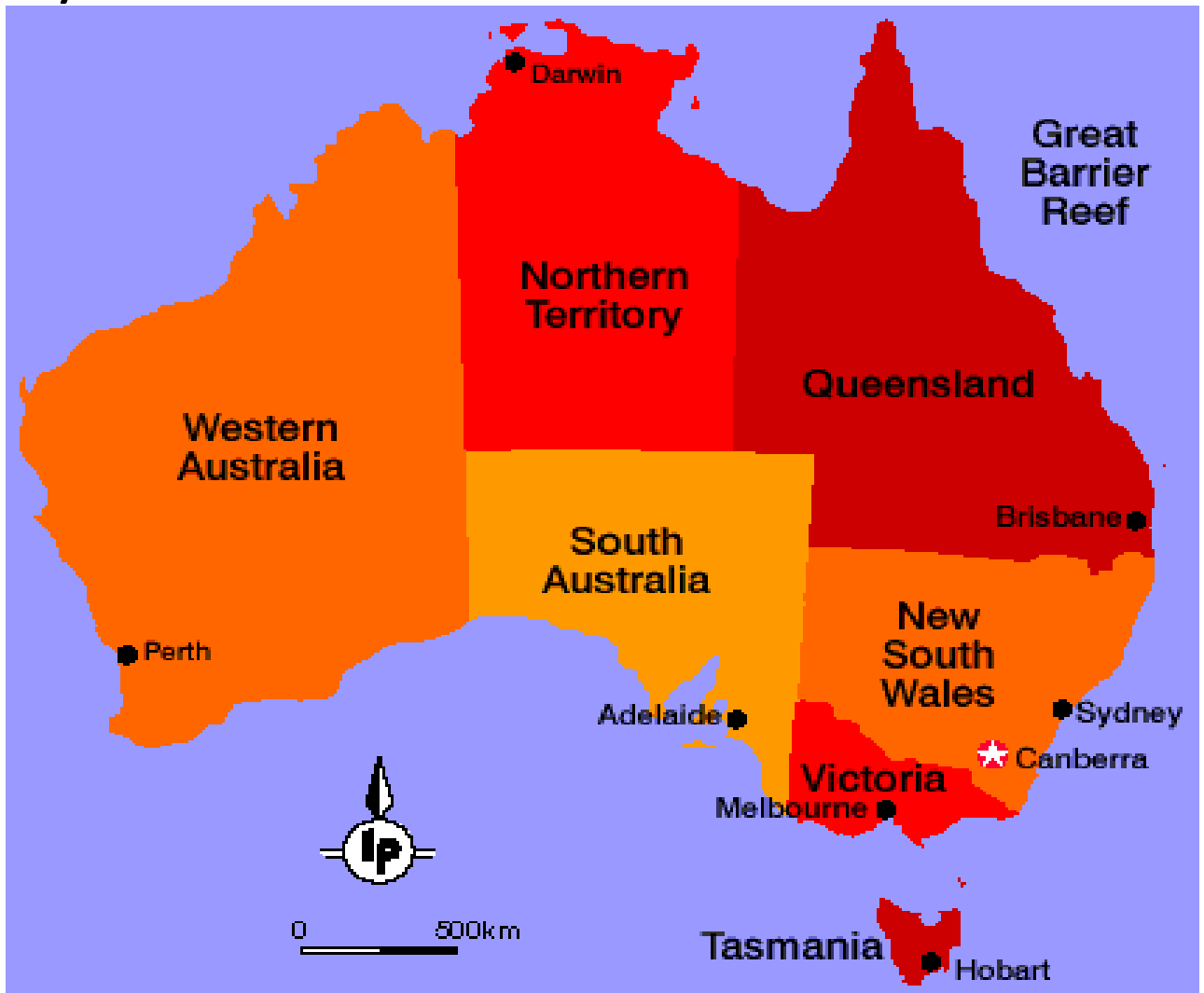
How to use Google CMR in COVID-19 studies?
---- Case Study in Australia

Research Questions: How is the change of human mobility adherent to policy and associated with COVID-19 transmission in Australia?

Background:



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How to use Google CMR in COVID-19 studies?
---- Case Study in Australia

Data:

Google CMR at the state and national level

COVID-19 data in Australia by state (Department of Public Health,2020)

Method:

1) Temporal analysis of mobility and policy implementation

2) Construction of a combined mobility index (CMI) --- calculated as the mean of the mobility of each type i in a day t:

$$\mathrm{CMI}(t) = \frac{\sum_{i=1}^{6} \mathrm{Mobility}_i}{6}.$$

How to use Google CMR in COVID-19 studies?
---- Case Study in Australia

Method:

3) Construction of two COVID-19 measures:

Growth rate (%) of confirmed cases at day t is calculated as:

$$GR(t) = \frac{C(t) - C(t-1)}{C(t-1)},$$

Doubling time (day) of confirmed cases at day t is calculated as:

$$DT(t) = \frac{Ln(2)}{Ln(1 + GR(t))}.$$

where C(t) is the cumulative number of confirmed cases at day t.

How to use Google CMR in COVID-19 studies?
---- Case Study in Australia

Method:

3) Selection of three modelling scenarios:

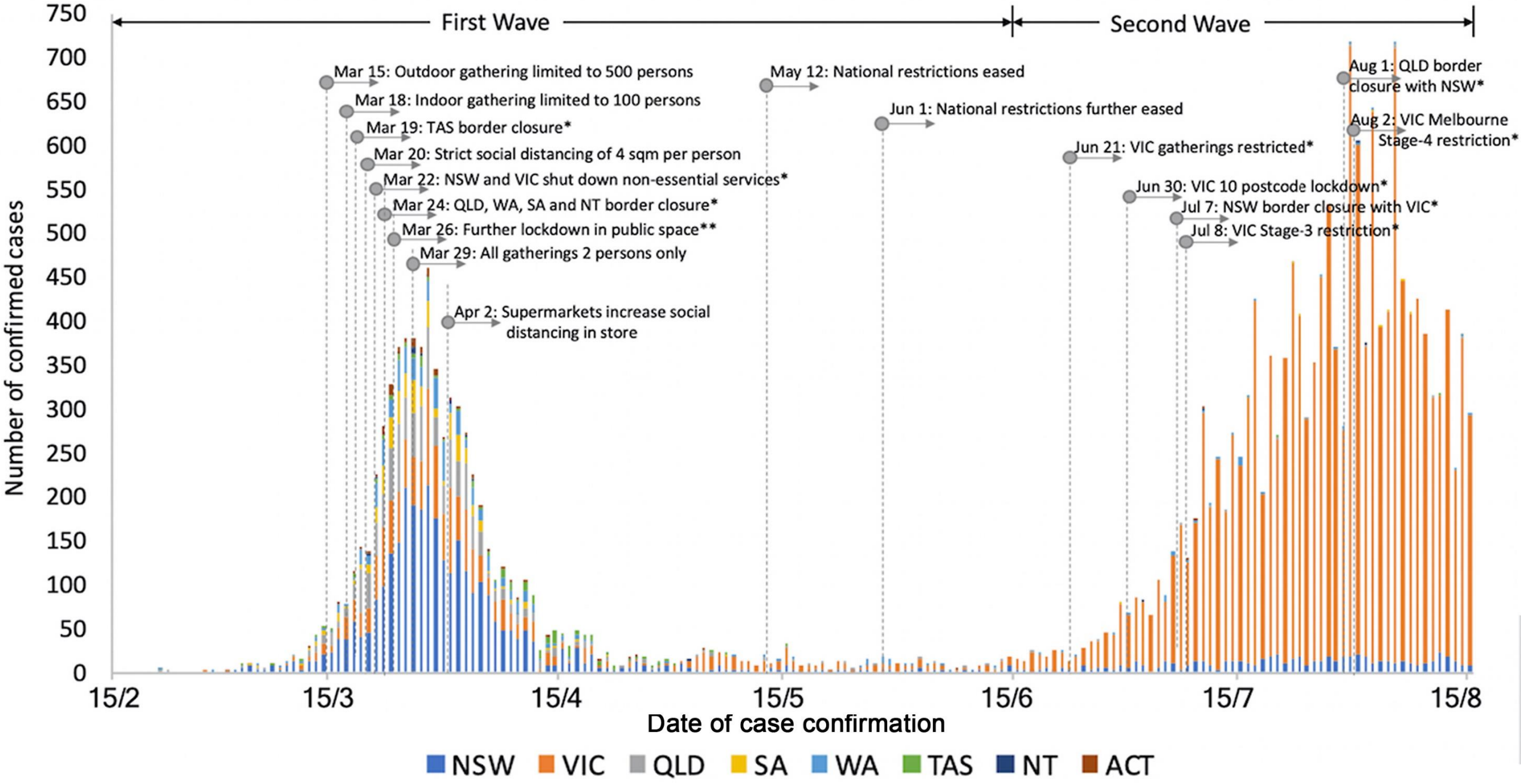
- right after the lockdown date
- 7 days after the lockdown date
- 14 days after the lockdown date

4) Pearson correlation analysis between CMI and GR/DT

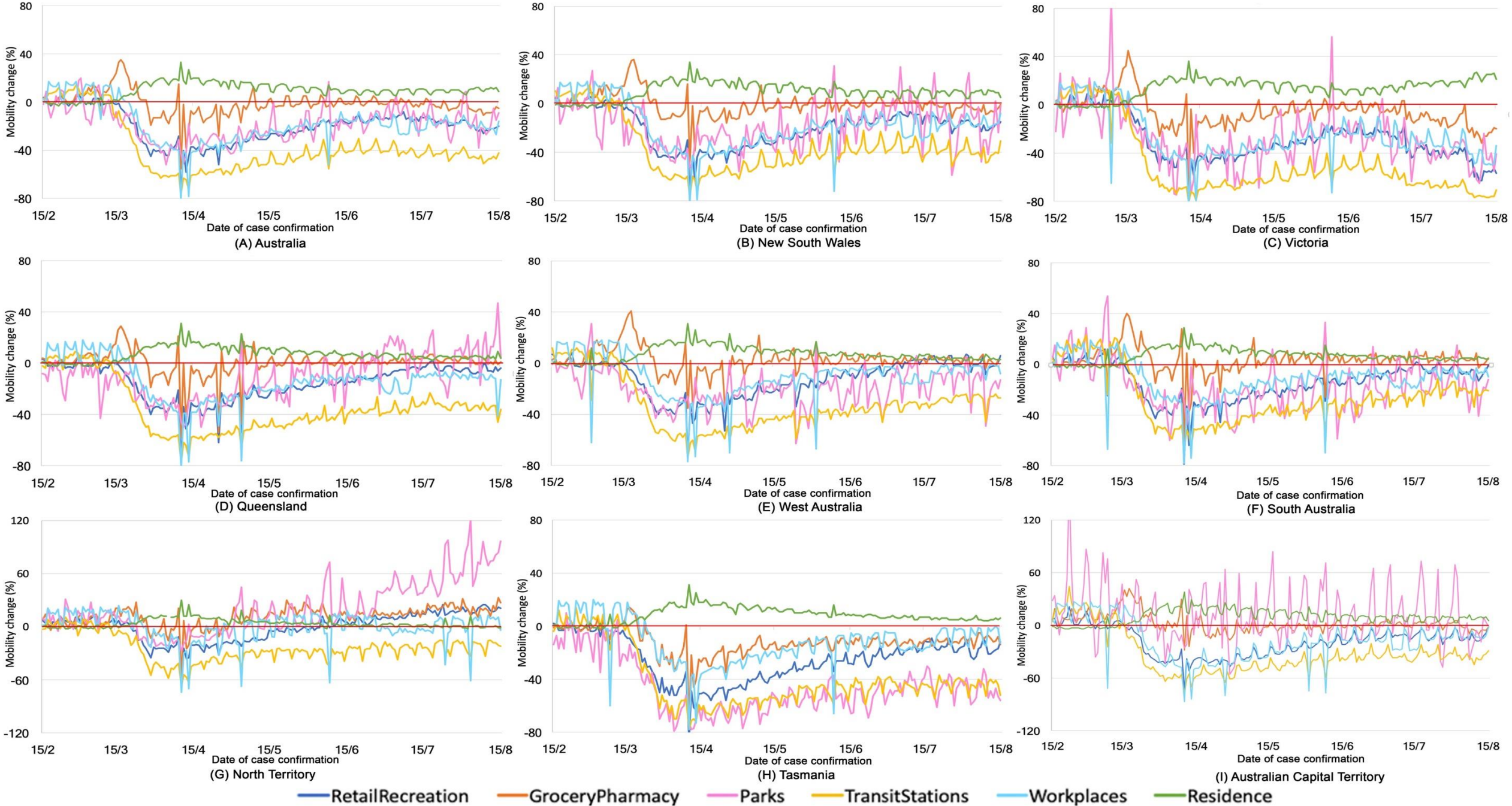
5) A panel regression analysis between six types of mobility changes and GR/DT

$$COV_{s,t} = \alpha_S + \beta_i Mob_{i,\, s,t-n} + \gamma_t + \varepsilon_{s,t} \qquad (n = 0, 1, \ldots, t-1),$$

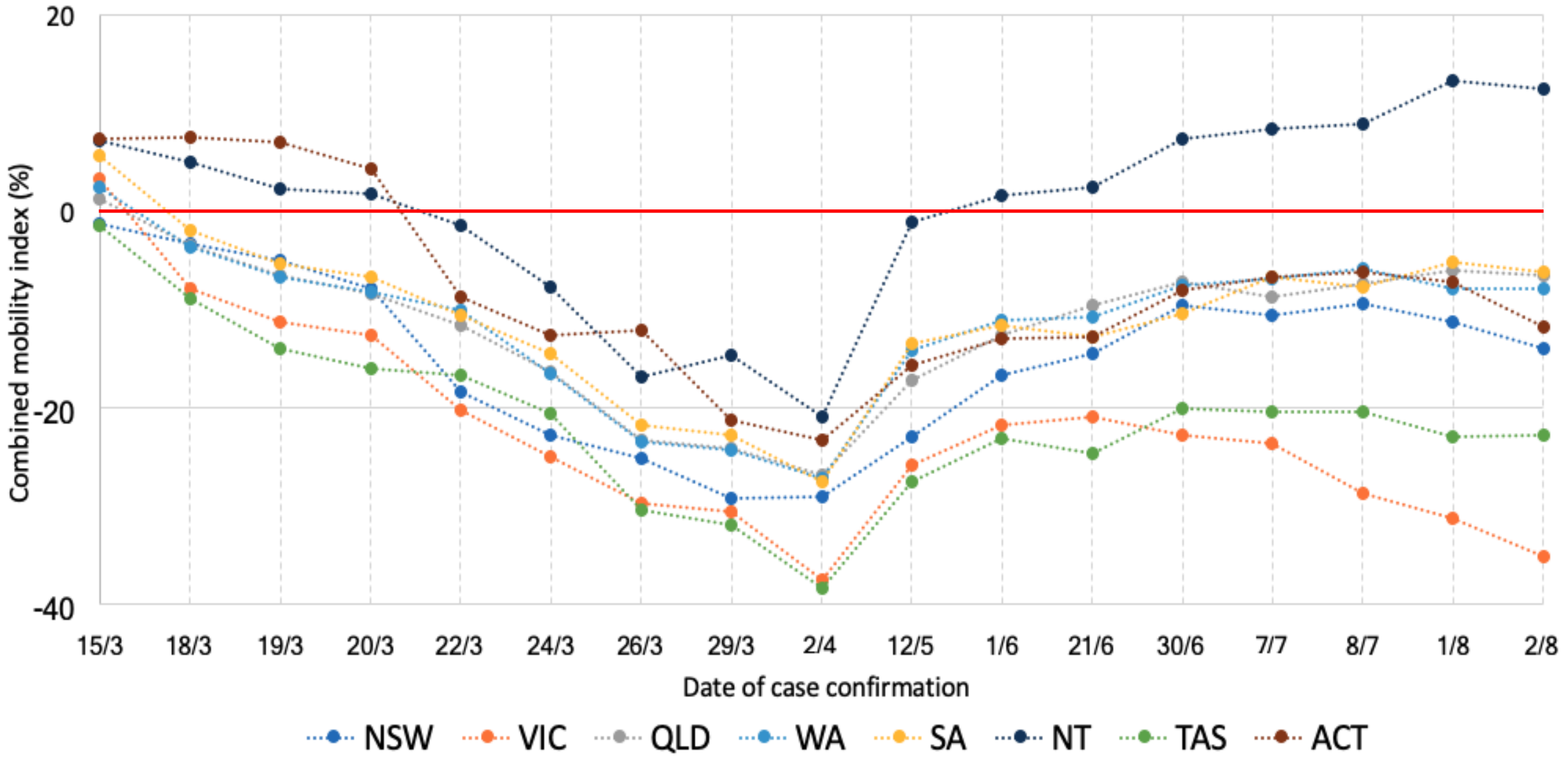
Results: The timeline of policy implementation



Temporal pattern of six types of mobility



Temporal pattern of Combined mobility index



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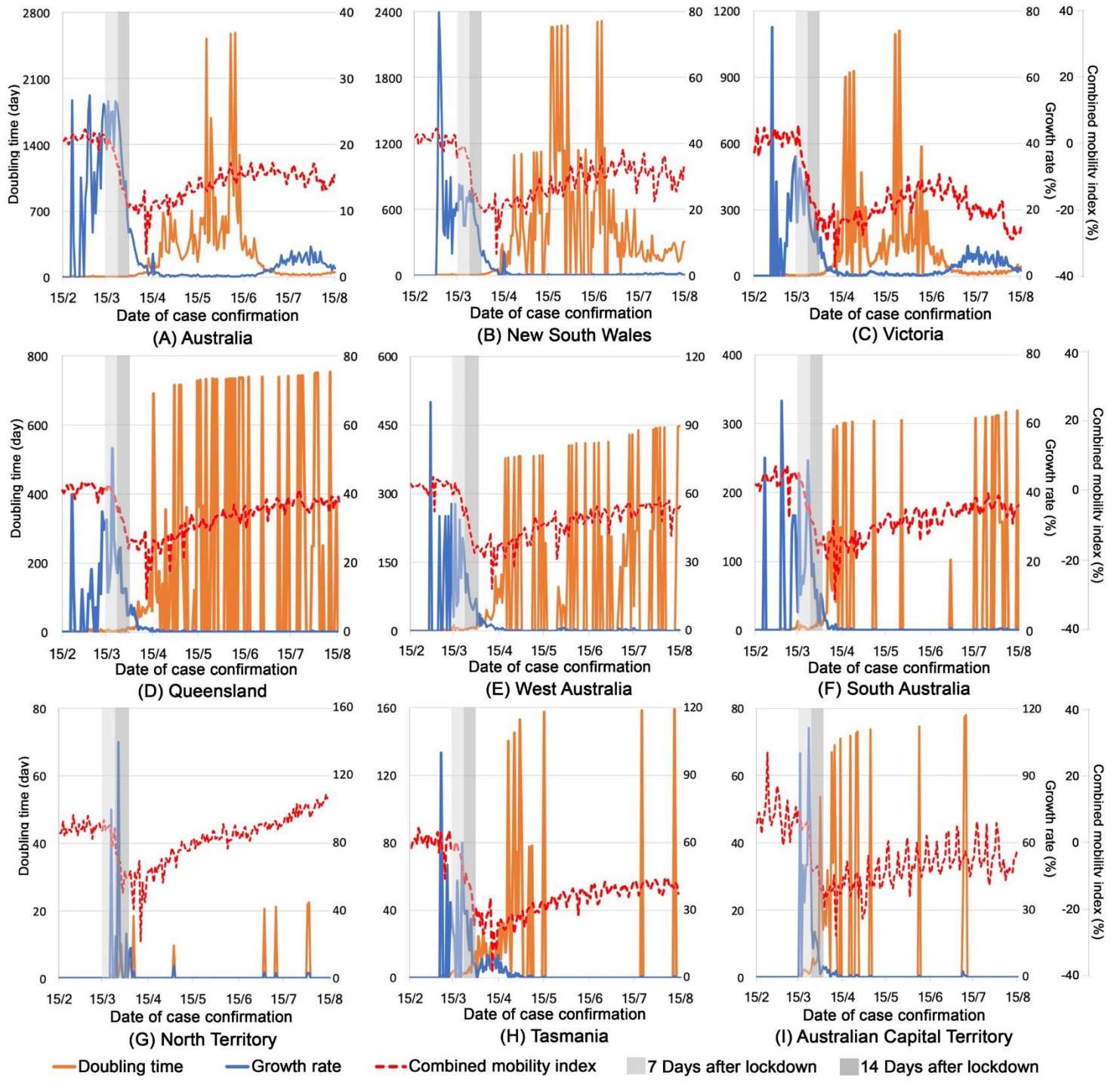
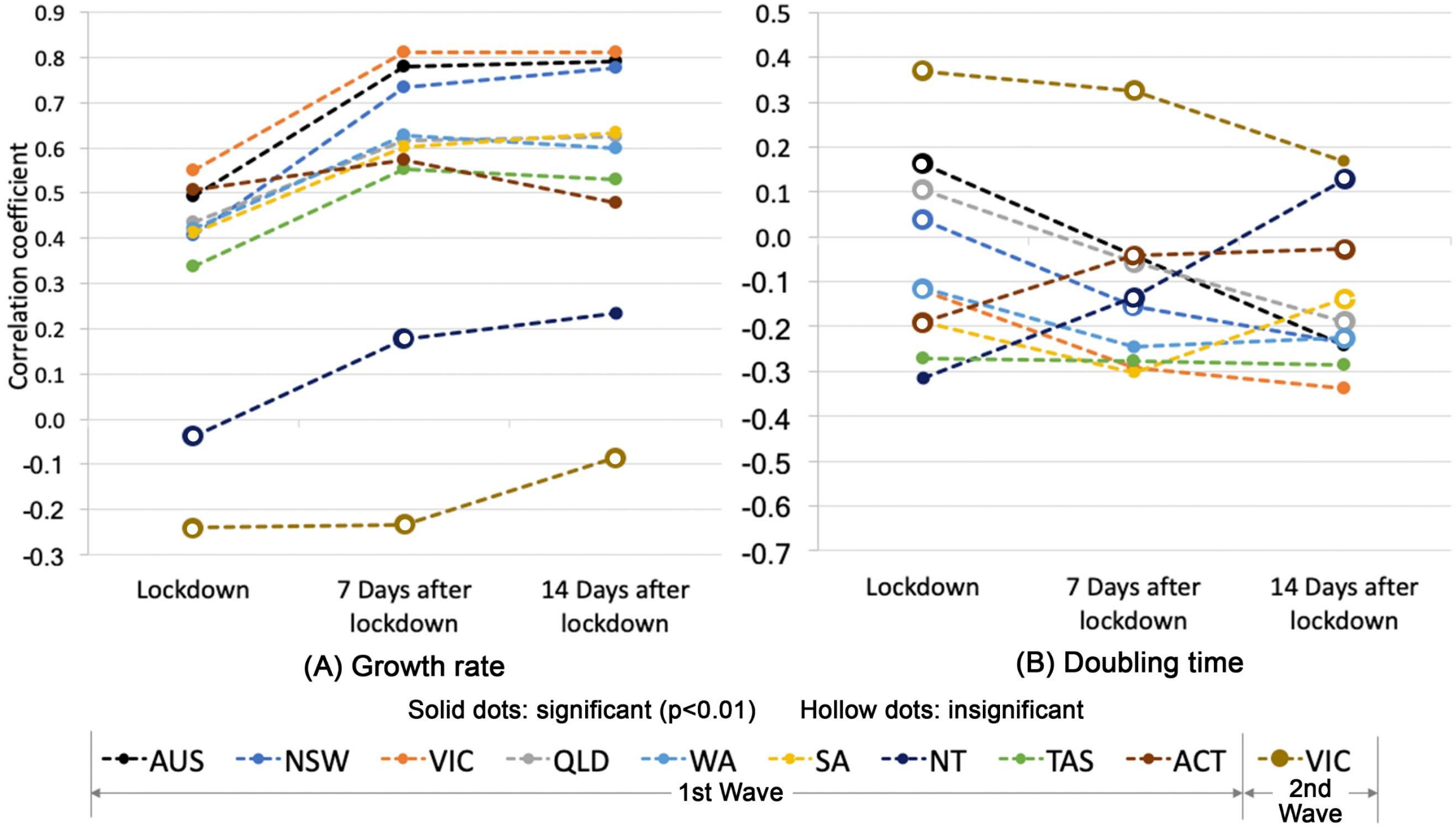
The Association between Human Mobility and COVID-19 Spread (growth rate/doubling time)



Correlation between mobility and growth rate/doubling time



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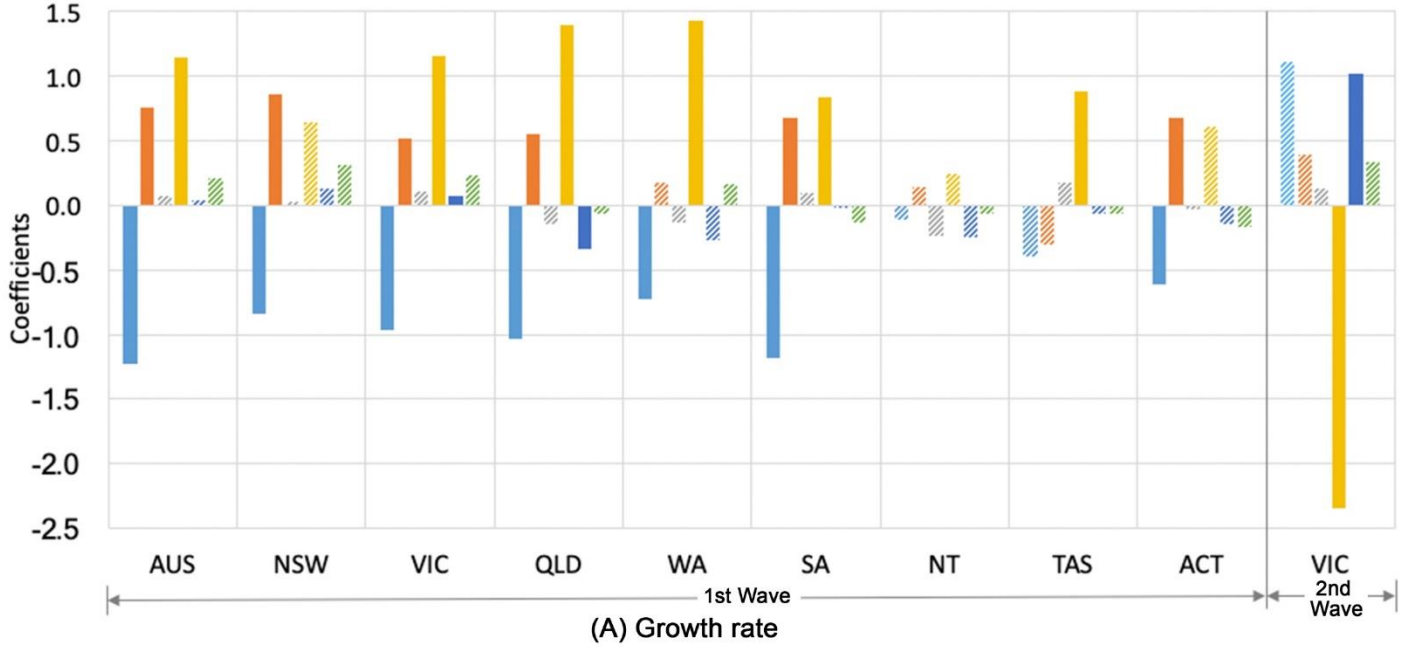
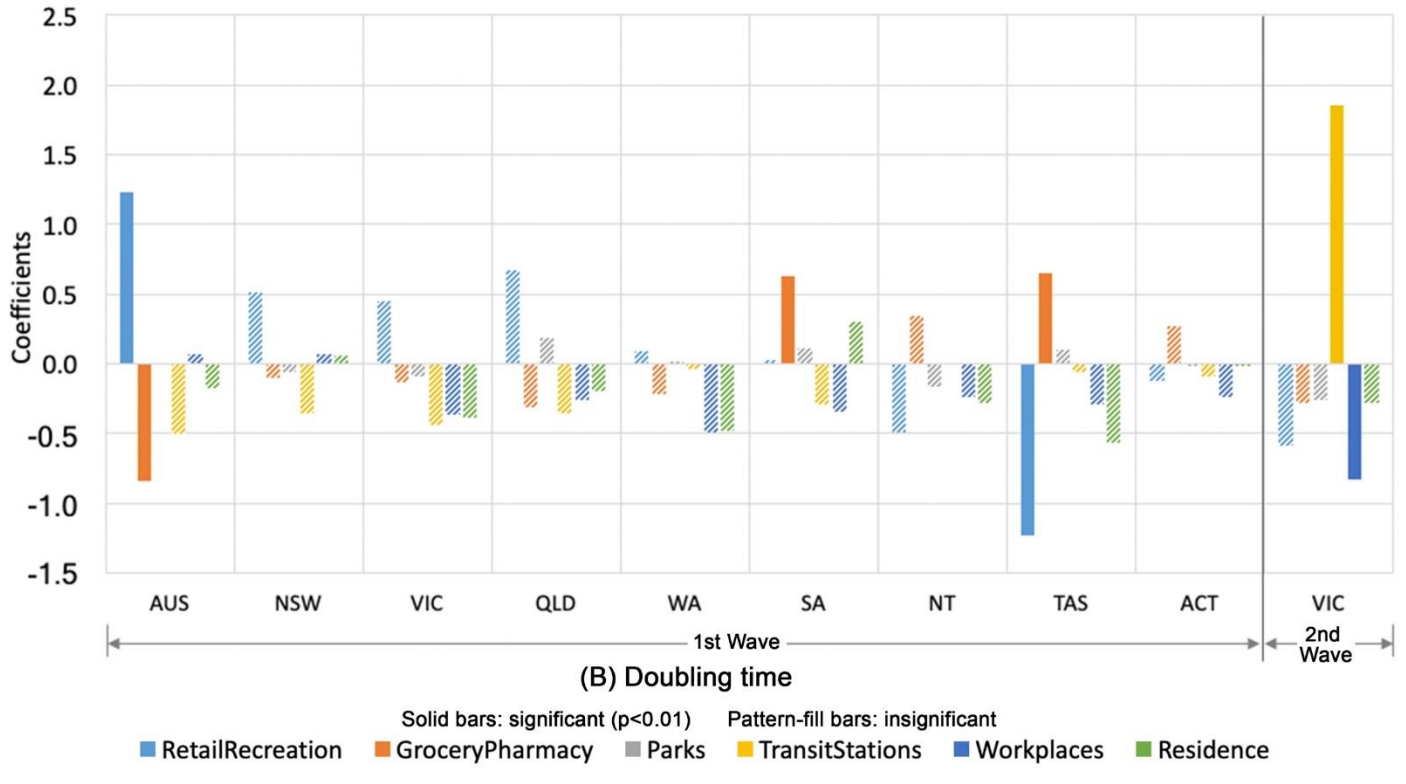
The panel regression between different types of mobility changes and growth rate/doubling time right after lockdown (Right after lockdown)





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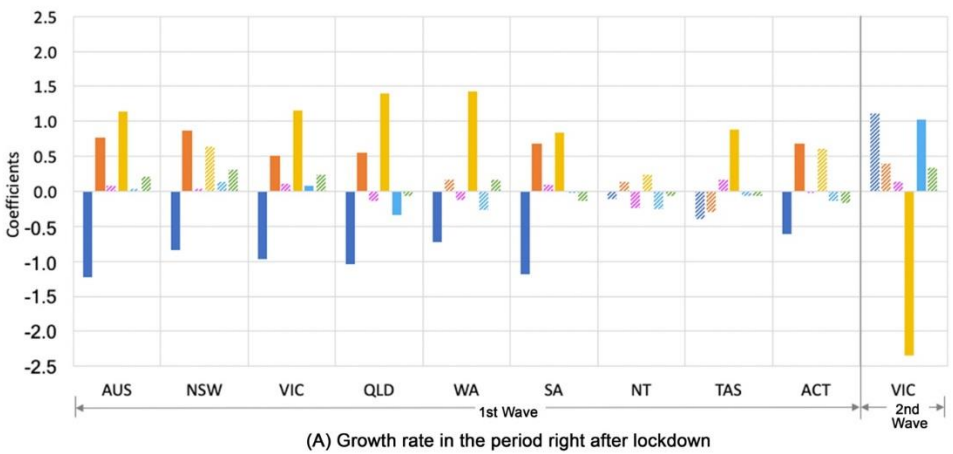
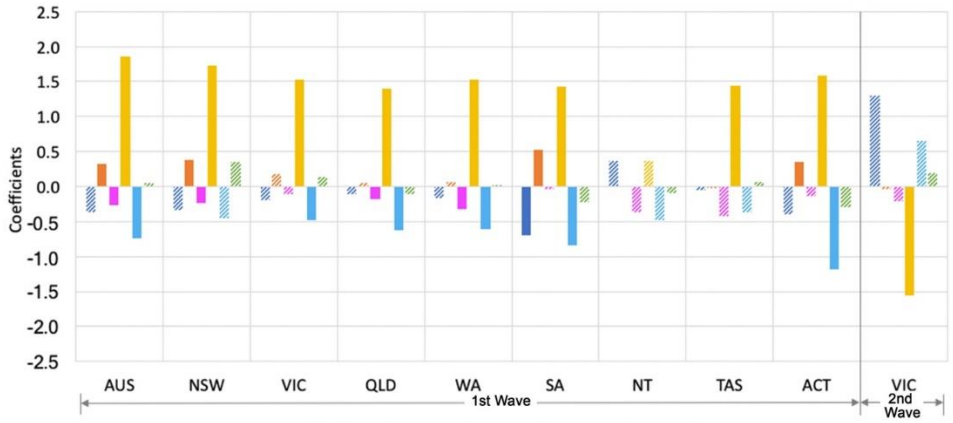
The panel regression between mobility changes and growth rate / doubling time in three time period:

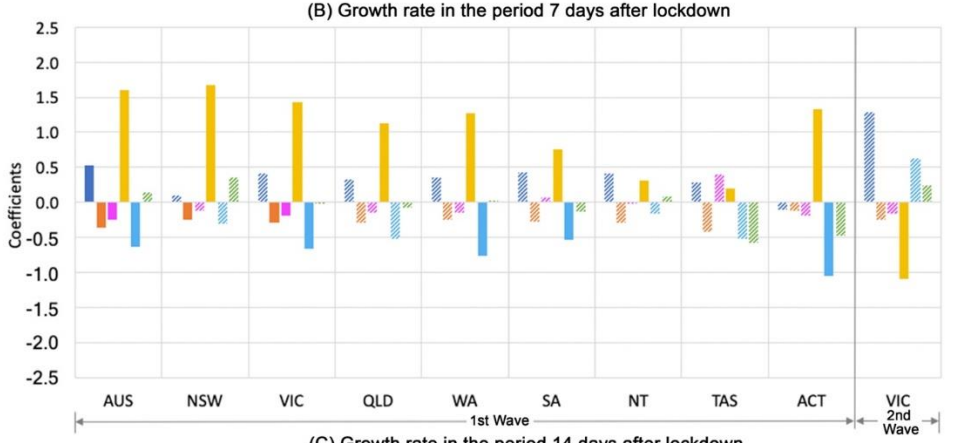
1) Right after lockdown
2) 7 days after lockdown
3) 14 days after lockdown



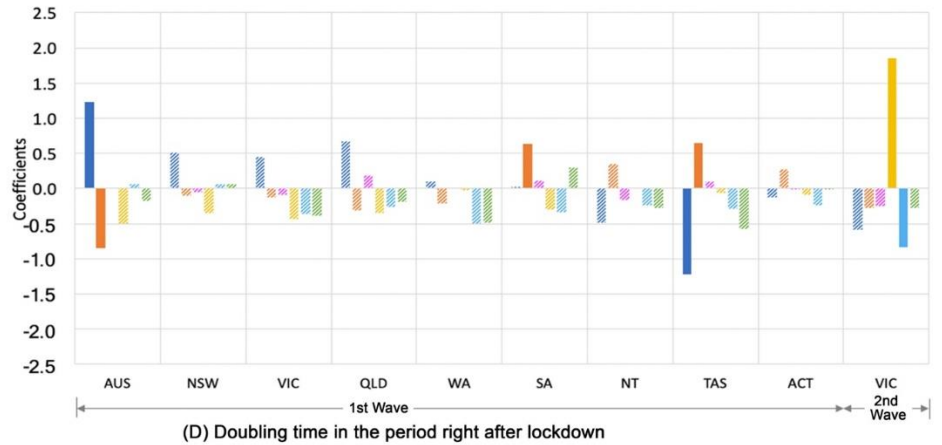
(A) Growth rate in the period right after lockdown



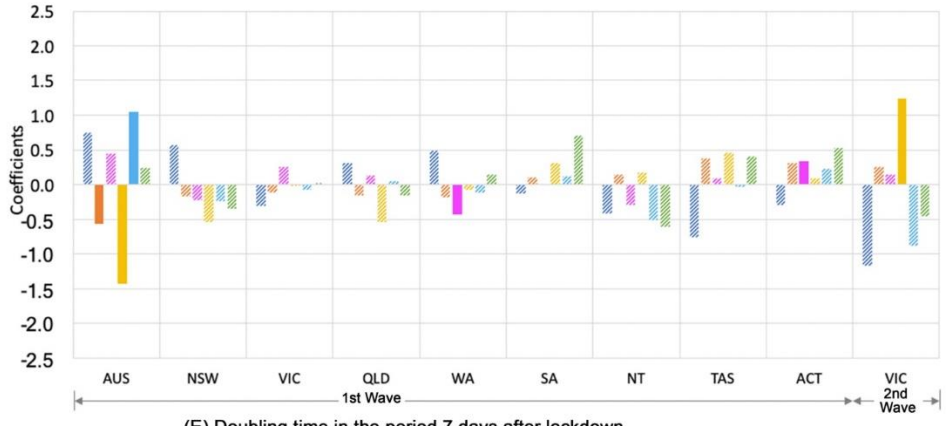
(B) Growth rate in the period 7 days after lockdown



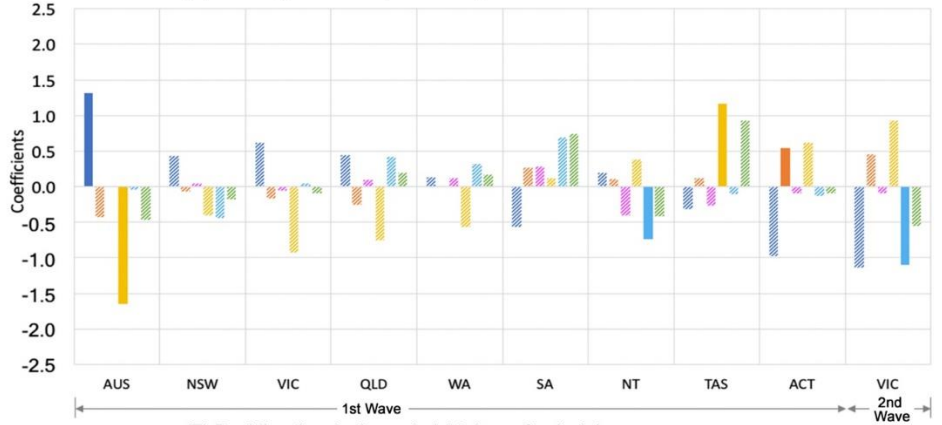
(C) Growth rate in the period 14 days after lockdown



(D) Doubling time in the period right after lockdown



(E) Doubling time in the period 7 days after lockdown



(F) Doubling time in the period 14 days after lockdown

Solid bars: significant (p<0.01) Pattern-fill bars: insignificant

RetailRecreation GroceryPharmacy Parks TransitStations Workplaces Residence

Conclusions

- First, a visual inspection of the COVID-19 cases and mobility level alongside the timeline of policy interventions in Australia suggests that social restriction policies controlled the COVID-19 spread effectively in the early stage of the first wave of the pandemic.
- Second, the control of mobility has a time lag effect on COVID-19 spread as the span of the mobility-spread relation lasts from 7 to 14 days, which is possibly tied to the incubation period.
- Third, there exists a dynamic association between mobility in different types and COVID-19 spread, and the magnitude of such an association varies across space and time.

Further studies on human mobility

sustainability

MDPI

https://doi.org/10.3390/su13105372

Review

A Bibliometric Analysis and Network Visualisation of Human Mobility Studies from 1990 to 2020: Emerging Trends and Future Research Directions

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Citation: Wang, S.; Zhang, M.; Hu, T.; Fu, X.; Gao, Z.; Halloran, B.; Liu, Y. A Bibliometric Analysis and Network Visualisation of Human Mobility Studies from 1990 to 2020: Emerging Trends and Future Research Directions. *Sustainability* **2021**, *13*, 5372. https://doi.org/10.3390/su13105372

Abstract: Studies on human mobility have a long history with increasingly strong interdisciplinary connections across social science, environmental science, information and technology, computer science, engineering, and health science. However, what is lacking in the current research is a synthesis of the studies to identify the evolutional pathways and future research directions. To address this gap, we conduct a systematic review of human mobility-related studies published from 1990 to 2020. Drawing on the selected publications retrieved from the Web of Science, we provide a bibliometric analysis and network visualisation using CiteSpace and VOSviewer on the number of publications and year published, authors and their countries and afflictions, citations, topics, abstracts, keywords, and journals. Our findings show that human mobility-related studies have become increasingly interdisciplinary and multi-dimensional, which have been strengthened by the use of the so-called 'big data' from multiple sources, the development of computer technologies, the

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Further studies on human mobility

Data and method

Research Protocol	Detail Description
Research database	WOS core collection: SCI-Expanded and SSCI
Publication type	All types: articles, review and editorial, conference proceeding papers, book chapters and review, meeting abstract, data papers, reprints, letters, correction and retracted publications.
Language	English
Year range	1990 to 2020 September
Search field	Topic including titles, abstracts, and keywords
Search term	Human mobility; mobility pattern; human trajectory; human migration; human immigration; population migration; population immigration; population mobility; rural mobility; urban mobility; migration flow; immigration flow; mobility network; migration network; immigration network
Data extraction	Export with full records and cited references in plain text format
Data analysis and visualisation	CiteSpace, VOSviewer
Sample size	5728 publications

Further studies on human mobility

Data and method

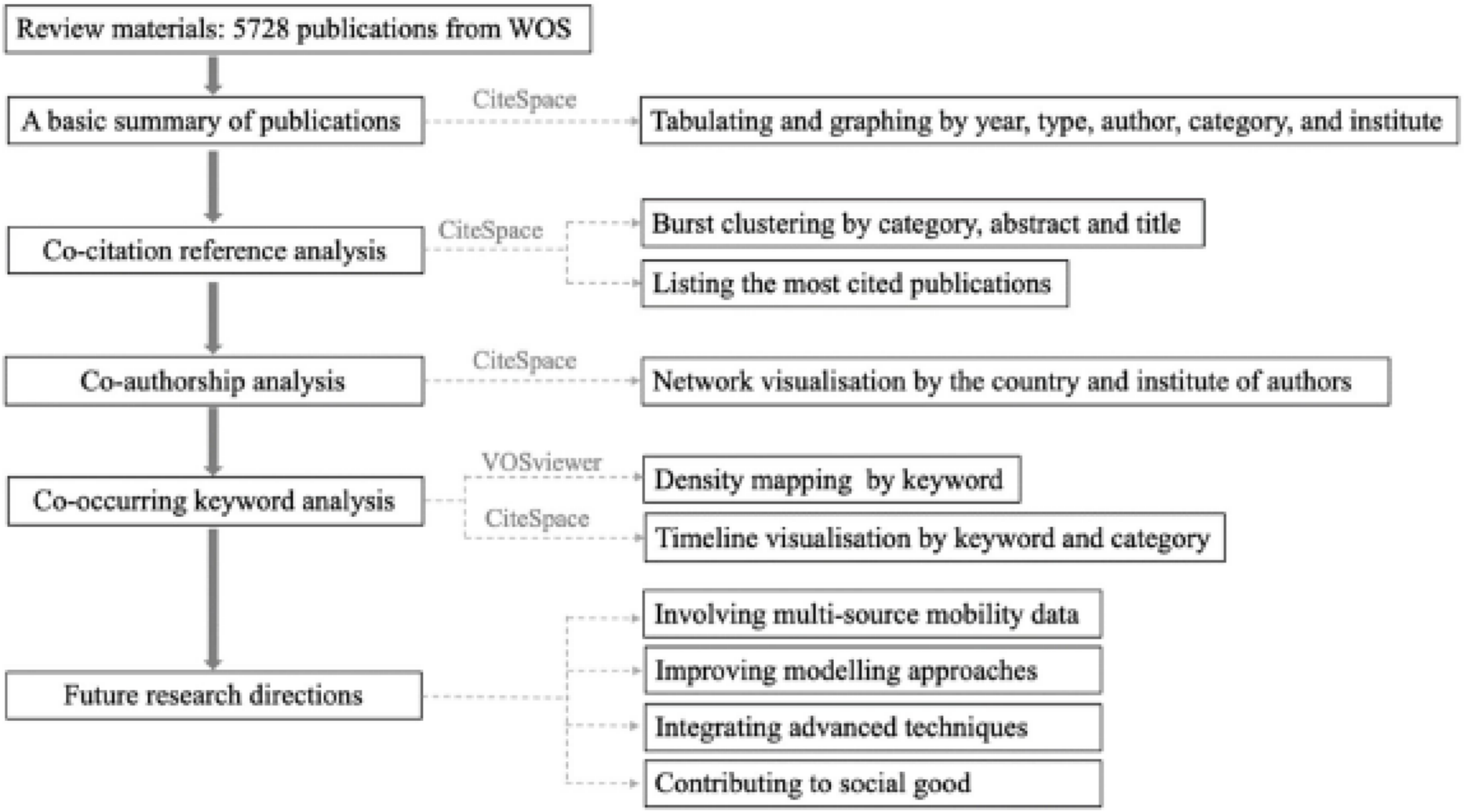


Figure 1. Analytical flowchart.

Key findings

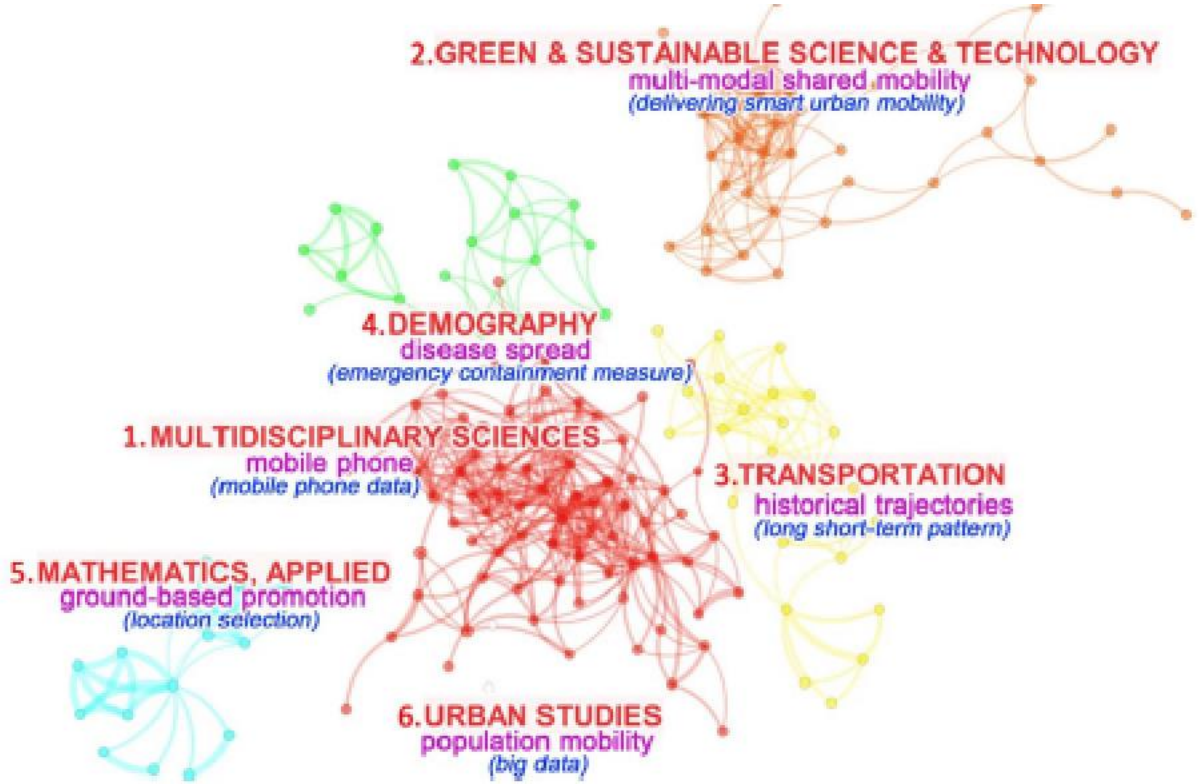


Figure 4. Bursts of co-citation references in the top six disciplinary categories (red label) w abstract terms (purple label) and title terms (blue label).

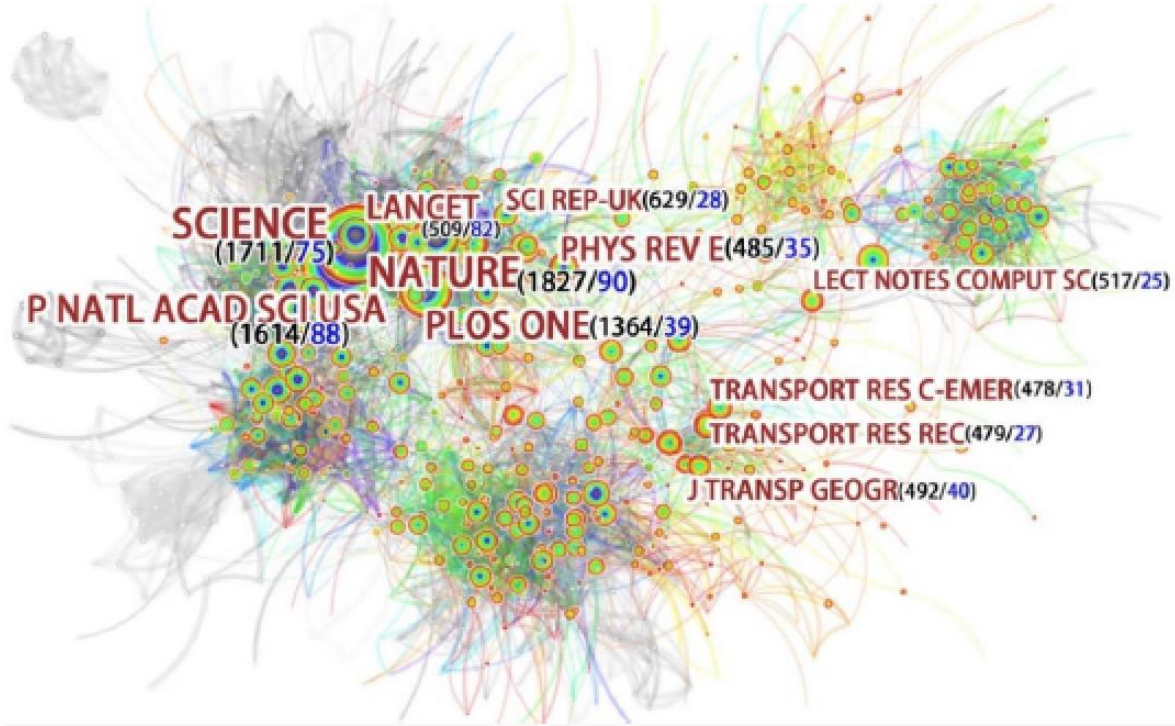


Figure 5. The most cited journals in co-citation references.

Key findings

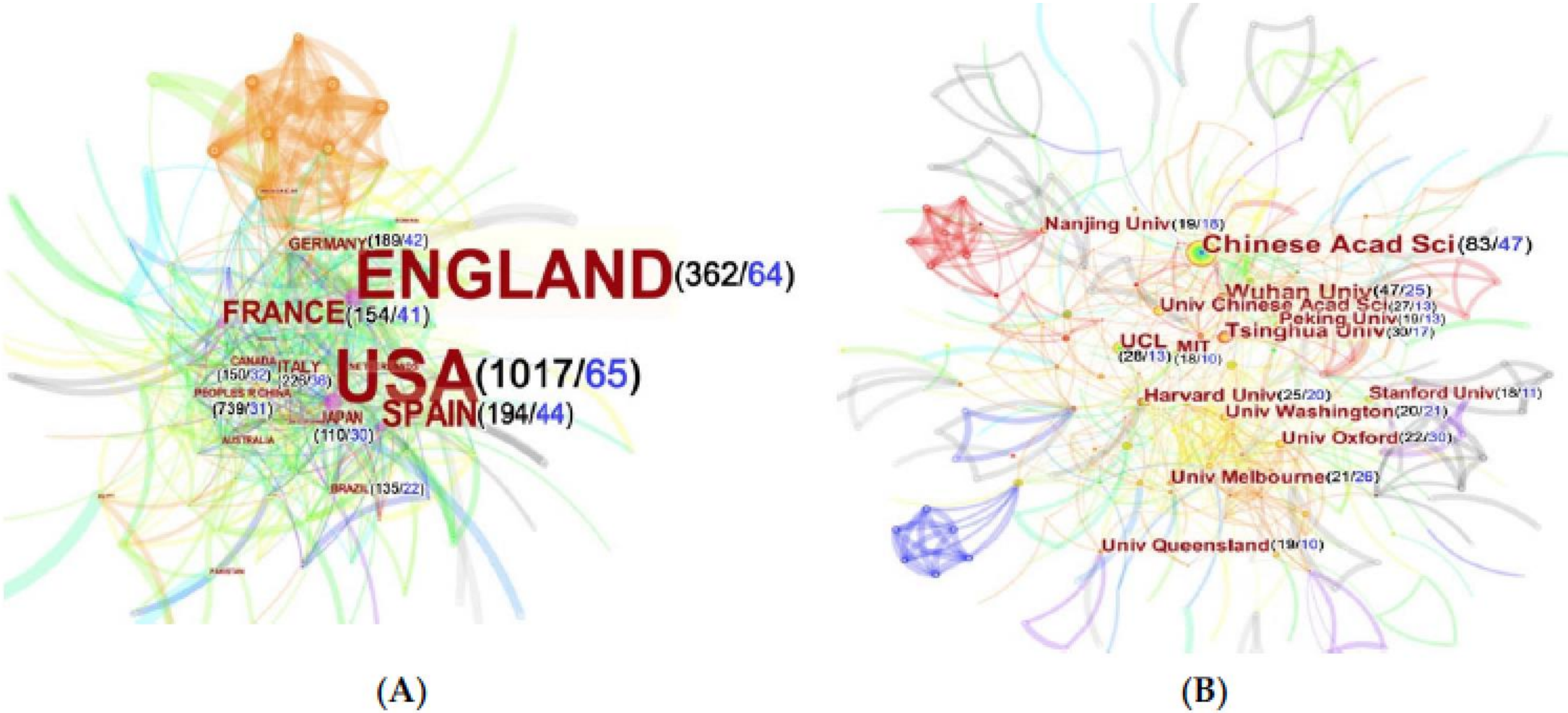


Figure 6. (A) Co-authorship analysis by country. (B) Co-authorship analysis by institution. Note: The number of publications is labelled in black and the betweenness degree (centrality) is labelled in blue.

Key findings

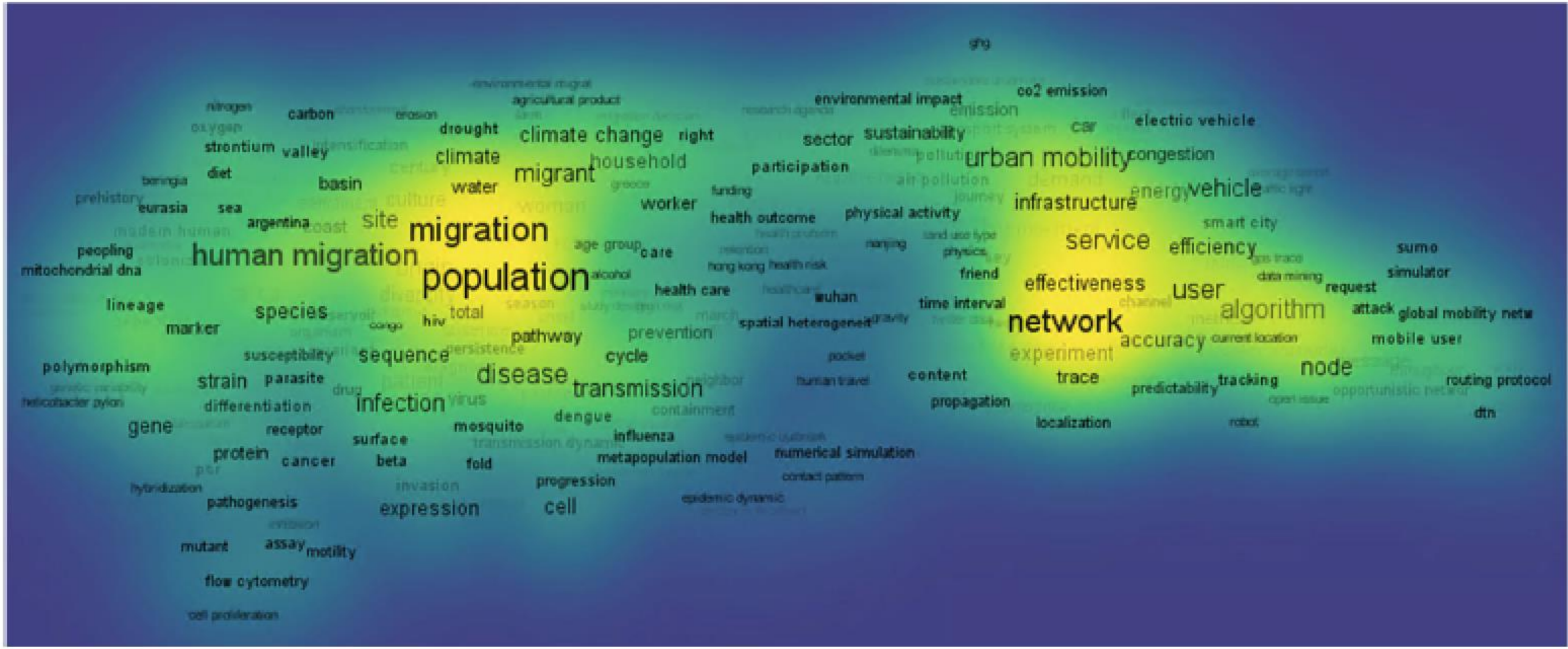
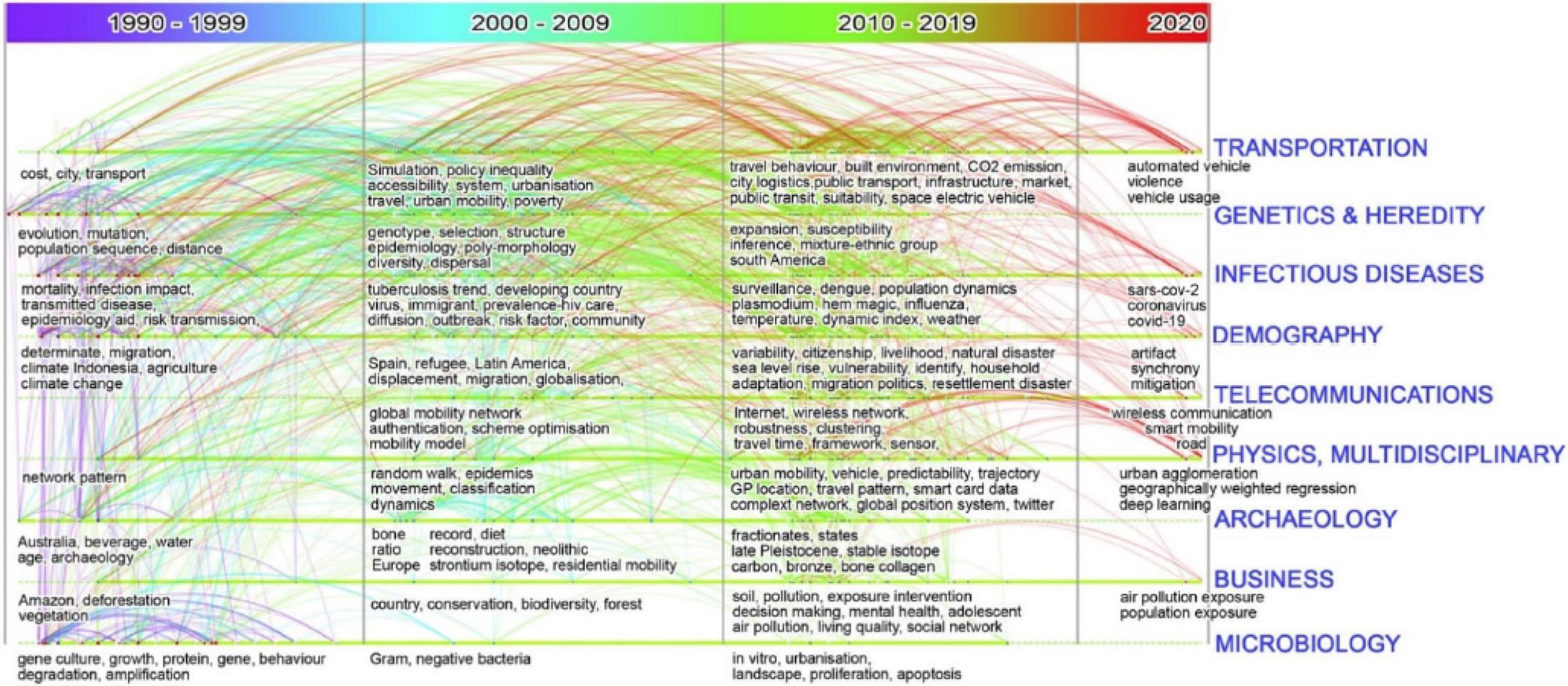


Figure 7. Keyword density visualisation.

Key findings



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Future directions of human mobility studies

1. The involvement of multi-source mobility data
2. The improvement of modelling individual and collective mobility patterns
3. The contribution of human mobility studies to social good
4. The integration of AI techniques in human mobility studies (e.g., machine learning, deep learning, etc)

QUESTIONS?
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