January 25th, 2020 (Lunar New Year's Day)

Preliminary risk analysis of 2019 novel coronavirus spread within and beyond China

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As of January 25th, 2020 (Beijing time), China has reported 1409 confirmed cases, 2032 suspected cases, and 42 deaths of 2019 Novel Coronavirus (2019-nCoV) infections, with most reported from Wuhan city, Hubei Province [1-3]. Nearly all provinces have confirmed imported cases from Wuhan and secondary transmission has been reported in some provinces. The spread of the virus could have been exacerbated by the surge in domestic travel during the 40-day Lunar New Year celebrations (from 10 January to 18 February 2020) – the largest annual human migration in the world, comprised of hundreds of millions of people travelling across the country.

We used de-identified and aggregated domestic population movement data from 2013 to 2015, derived from Baidu Location-Based Services (LBS) [4], and international air travel data in 2018, obtained from the International Air Transport Association (IATA) [5], to explore patterns of mobility of travellers from Wuhan to other cities in China, and inform the risk of 2019-nCoV spreading across and beyond the country during the Lunar New Year migration.

Using the 2013-2015 LBS data, we found that a large number of travellers were likely departing Wuhan into neighbouring cities and other megacities in China before Lunar New Year (Figures 1-3 and Tables 1-3). There was a high correlation between the number of imported cases and the risk of importation via travellers from Wuhan within the two weeks before Lunar New Year's Day (Figure 4). Further, a high proportion of cases travelled with symptoms at the early stage of the outbreak. Although a cordon sanitaire of Wuhan and some cities in Hubei Province has been in place since January 23rd, 2020, the timing of this may have occurred during the latter stages of peak population numbers leaving Wuhan (Figure 1). Should secondary outbreaks occur in the cities and provinces that receive high volumes of travellers from Wuhan, e.g. Beijing, Shanghai, and Guangzhou, these could contribute to further spread of infection to other highly connected cities within China via movement after the 7-day public holiday (Figures 5-7). Additionally, based on historical air travel data, the connectivity between high-risk cities in China and other countries was defined for the three months around Lunar New Year holiday (Tables 4 and 5). We have initially focussed on specific destination cities in Africa due to the weak surveillance and health systems of this vulnerability region (Tables 6-7 and Figures 8-9), but will expand similar assessments to the rest of the World.

Given the current epidemic and limited understanding of the epidemiology of this disease, our findings of travel patterns from historical data could help contribute to tailoring public health interventions. However, it is important to highlight that our analysis assumes "business as usual" travel based on previous non-outbreak years and we are currently in unprecedented territory, with likely significant changes to human travel behaviours across China. We are closely monitoring the epidemic, and further analyses will be conducted to estimate the risk of onward domestic and international spread of the virus during the Lunar New Year and the next few months. Moreover, we will also attempt to evaluate the effectiveness of the transport lockdown in Chinese cities, and the impact of movements of people returning from holiday on the transmission of the 2019-nCoV virus.

Reference

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2. Chan J, et al. (2020) A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet. DOI: 10.1016/S0140-6736(20)30154-9
3. Huang C, et al. (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. DOI: 10.1016/S0140-6736(20)30183-5
4. Baidu Migration. http://qianxi.baidu.com/
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Section I. Domestic Travel

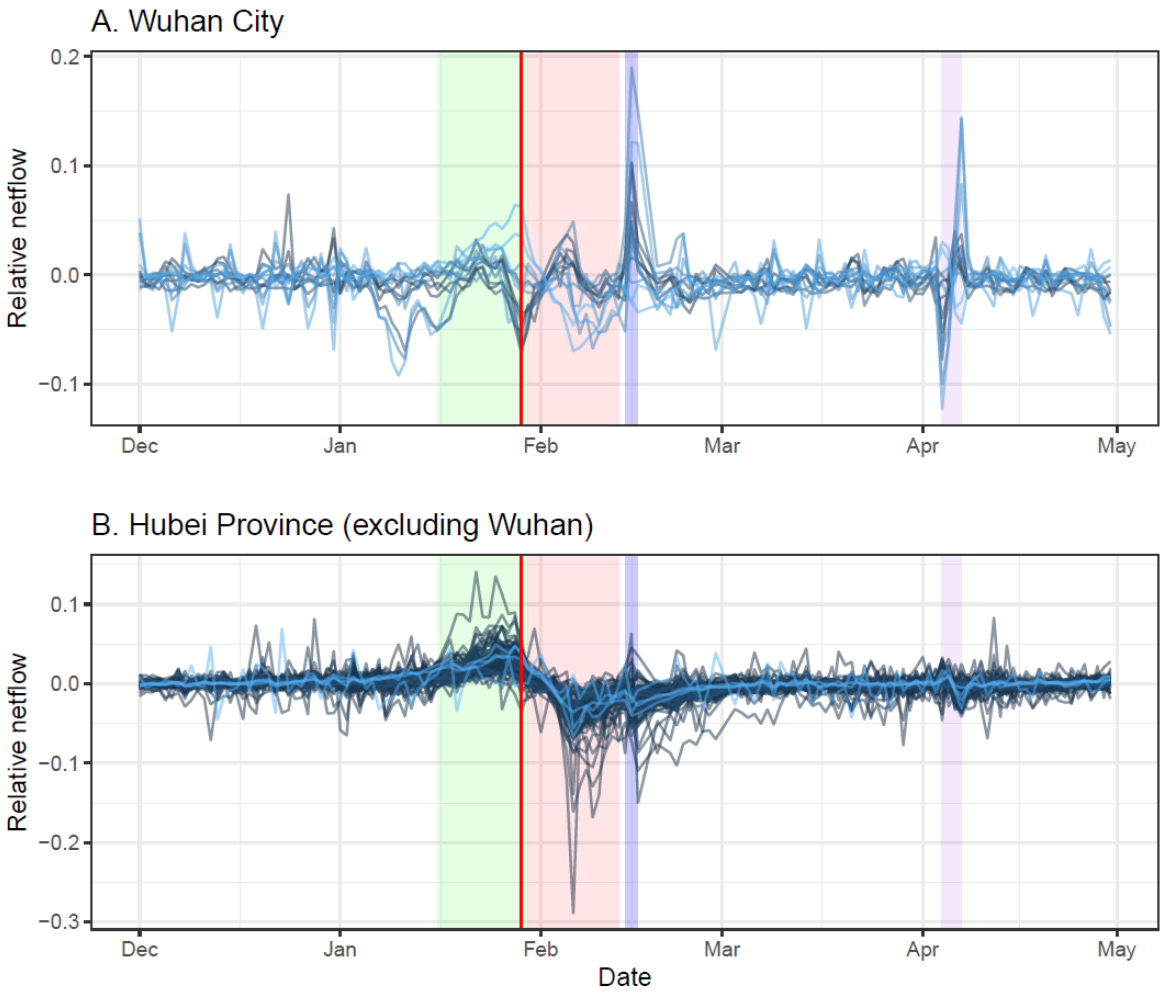

Figure 1. Patterns of daily human movement by county in Wuhan City and Hubei Province across six months.

Shadow colours:

- Green: 2 weeks before Lunar New Year's Day;
- Red: 2 weeks since Lunar New Year's Day;
- Purple: Lantern Festival;
- Pink: Tomb Sweeping Day;
- Red line: Lockdown day of cities in Hubei.

Relative netflow = (Inflow – Outflow)/population, based on the population movement data in 2013-2014 from Baidu, Inc.

Table 1. Top 30 ranked cities in mainland China receiving travellers from Wuhan during the two weeks before Lunar New Year's Day.

Rank	City	Population (million)*	Province	Volume (%)**
1	Jingzhou	5.7	Hubei	7.26
2	Xiangfan	5.6	Hubei	7.11
3	Xianning	2.5	Hubei	6.17
4	Beijing	21.7	Beijing	6.10
5	Huanggang	6.3	Hubei	5.94
6	Yichang	4.1	Hubei	5.86
7	Huangshi	2.5	Hubei	5.18
8	Xiaogan	4.9	Hubei	4.73
9	Sheng Zhixia	3.5	Hubei	4.62
10	Shiyan	3.4	Hubei	4.14
11	Shanghai	24.2	Shanghai	3.52
12	Enshi	3.3	Hubei	3.51
13	Jingmen	2.9	Hubei	3.06
14	Suizhou	2.2	Hubei	2.49
15	Guangzhou	14.0	Guangdong	2.45
16	Zhengzhou	9.6	Henan	2.22
17	Ezhou	1.1	Hubei	1.93
18	Tianjin	15.6	Tianjin	1.56
19	Jiaxing	4.6	Zhejiang	1.25
20	Hangzhou	9.0	Zhejiang	1.23
21	Changsha	7.6	Hunan	1.13
22	Xi'an	8.3	Shaanxi	1.02
23	Nanjing	8.3	Jiangsu	0.97
24	Shenzhen	10.2	Guangdong	0.96
25	Chongqing	30.9	Chongqing	0.82
26	Fuzhou	7.6	Fujian	0.58
27	Nanchang	5.4	Jiangxi	0.57
28	Chengdu	14.3	Sichuan	0.56
29	Hefei	7.9	Anhui	0.52
30	Dongguan	8.3	Guangdong	0.45
	Other	1115.8		12.09
	Total	1371.5		100.00

* 2016 population, National Bureau of Statistics, P.R. China.

** Percentage of travellers leaving Wuhan city within 2 weeks before the Lunar New Year in 2014 and 2015. Data were obtained from Baidu, Inc., a Chinese technology company specializing in Internet-related and location-based services with nearly 9 billion location requests each day.

Table 2. Top 30 ranked cities in mainland China receiving travellers from Wuhan during the two weeks since Lunar New Year's Day.

Rank	City	Population (million)*	Province	Volume (%)**
1	Yichang	4.1	Hubei	7.48
2	Jingzhou	5.7	Hubei	6.65
3	Xiangfan	5.6	Hubei	6.48
4	Huanggang	6.3	Hubei	5.91
5	Beijing	21.7	Beijing	5.56
6	Xiaogan	4.9	Hubei	5.16
7	Xianning	2.5	Hubei	4.25
8	Sheng Zhixia	3.5	Hubei	4.22
9	Shanghai	24.2	Shanghai	3.97
10	Shiyan	3.4	Hubei	3.89
11	Jingmen	2.9	Hubei	3.51
12	Huangshi	2.5	Hubei	3.46
13	Guangzhou	14.0	Guangdong	3.07
14	Enshi	3.3	Hubei	3.01
15	Suizhou	2.2	Hubei	2.50
16	Ezhou	1.1	Hubei	2.26
17	Zhengzhou	9.6	Henan	2.13
18	Changsha	7.6	Hunan	1.78
19	Tianjin	15.6	Tianjin	1.65
20	Shenzhen	10.2	Guangdong	1.24
21	Xi'an	8.3	Shaanxi	1.24
22	Nanjing	8.3	Jiangsu	1.13
23	Hangzhou	9.0	Zhejiang	1.12
24	Jiaxing	4.6	Zhejiang	1.04
25	Nanchang	5.4	Jiangxi	0.83
26	Chongqing	30.9	Chongqing	0.82
27	Fuzhou	7.6	Fujian	0.82
28	Hefei	7.9	Anhui	0.78
29	Suzhou	10.6	Jiangsu	0.51
30	Dongguan	8.3	Guangdong	0.47
	Other	1119.5		13.04
	Total	1371.5		100.00

* 2016 population, National Bureau of Statistics, P.R. China.

** Percentage of travellers leaving Wuhan city within 2 weeks since the first day of the Lunar New Year in 2014 and 2015. Data were obtained from Baidu, Inc., a Chinese technology company specializing in Internet-related and location-based services with nearly 9 billion location requests each day.

Table 3. The rank of provinces in mainland China receiving travellers from Wuhan city around Lunar New Year's Day.

	Within 2 weeks before Lunar New Year			Within 2 weeks since Lunar New Year		
Rank	Province*	Population (million) [a]	Volume (%) [b]	Province*	Population (million) [a]	Volume (%) [b]
1	Beijing	21.5	16.07	Beijing	21.5	13.50
2	Guangdong	113.5	12.19	Guangdong	113.5	13.32
3	Henan	96.1	9.48	Shanghai	24.2	9.64
4	Shanghai	24.2	9.25	Henan	96.1	7.95
5	Zhejiang	57.4	8.19	Zhejiang	57.4	7.22
6	Jiangsu	80.5	5.51	Jiangsu	80.5	6.81
7	Hunan	69.0	4.80	Hunan	69.0	6.29
8	Shaanxi	38.6	4.54	Shaanxi	38.6	4.98
9	Tianjin	15.6	4.11	Tianjin	15.6	4.00
10	Shandong	100.5	3.66	Shandong	100.5	3.89
11	Sichuan	83.4	3.13	Fujian	39.4	3.70
12	Jiangxi	46.5	2.75	Anhui	63.2	3.27
13	Fujian	39.4	2.72	Jiangxi	46.5	2.90
14	Anhui	63.2	2.62	Sichuan	83.4	2.13
15	Chongqing	31.0	2.15	Chongqing	31.0	2.00
16	Hebei	75.6	1.94	Hebei	75.6	1.74
17	Yunnan	48.3	1.22	Liaoning	43.6	1.21
18	Guangxi	49.3	1.10	Yunnan	48.3	1.08
19	Liaoning	43.6	1.06	Guangxi	49.3	1.00
20	Hainan	9.3	0.58	Shanxi	37.2	0.62
21	Shanxi	37.2	0.54	Hainan	9.3	0.48
22	Guizhou	36.0	0.47	Guizhou	36.0	0.46
23	Heilongjiang	37.7	0.40	Heilongjiang	37.7	0.41
24	Xinjiang	24.9	0.40	Xinjiang	24.9	0.33
25	Gansu	26.4	0.32	Jilin	27.0	0.31
26	Jilin	27.0	0.31	Gansu	26.4	0.26
27	Inner Mongolia	25.3	0.29	Inner Mongolia	25.3	0.25
28	Ningxia	6.9	0.11	Ningxia	6.9	0.11
29	Qinghai	6.0	0.07	Qinghai	6.0	0.10
30	Tibet	3.4	0.03	Tibet	3.4	0.03

* All provinces except Tibet and Qinghai have reported imported or local confirmed cases, as of 08:20 on January 25th, 2020 (Beijing time).

[a] 2016 population, National Bureau of Statistics, P.R. China.

[b] Percentage of travellers leaving Wuhan city within 2 weeks since the first day of the Lunar New Year in 2014 and 2015. Data were obtained from Baidu, Inc., a Chinese technology company specializing in Internet-related and location-based services with nearly 9 billion location requests each day.

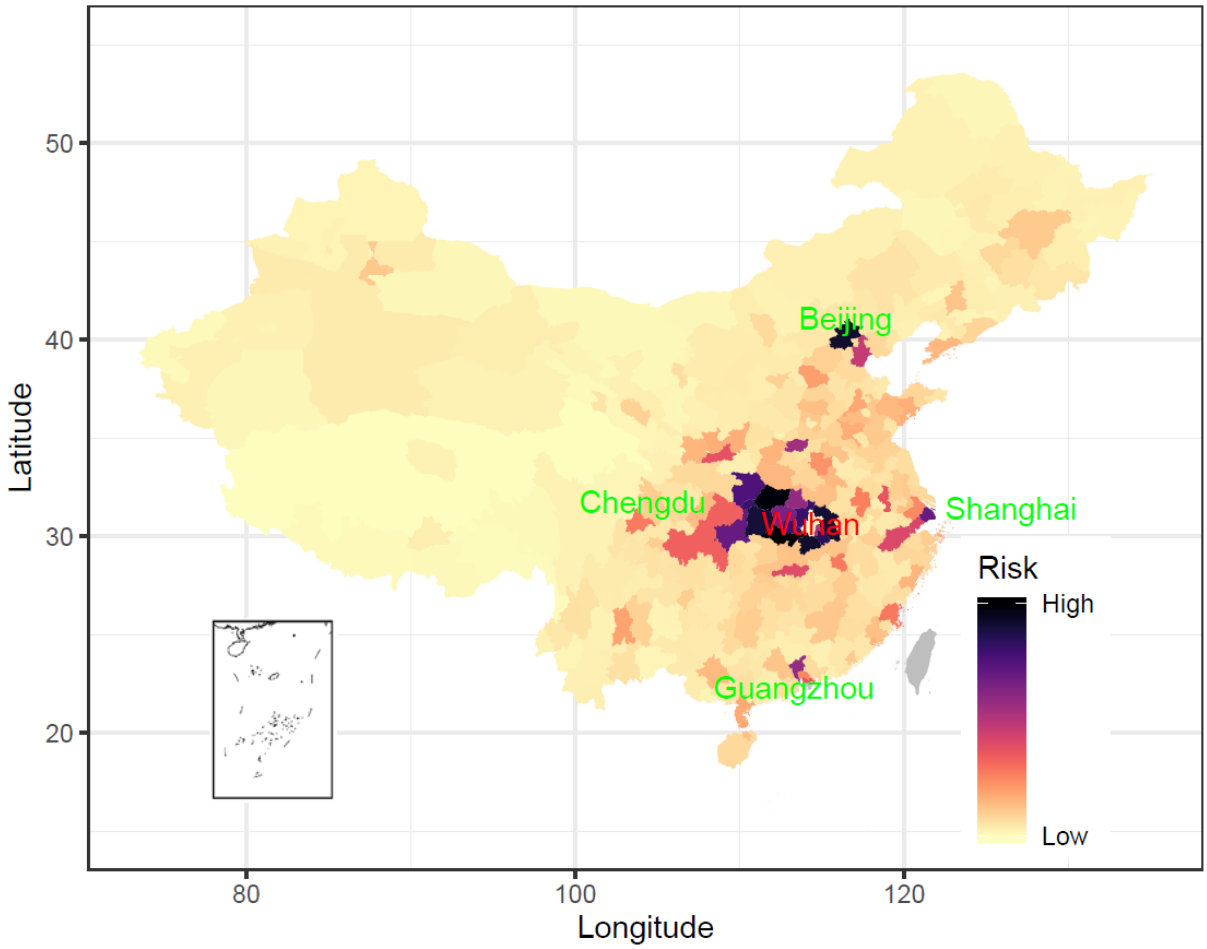

Figure 2. Risk of cities in mainland China receiving travellers with 2019-nCoV infections from Wuhan during the Lunar New Year migration.

The risk of importation at city level was preliminarily defined as the percentage of travellers received by each city out of the total volume of travellers leaving Wuhan within 2 weeks before and since the first day of Lunar New Year, based on the population movement data from Baidu, Inc.

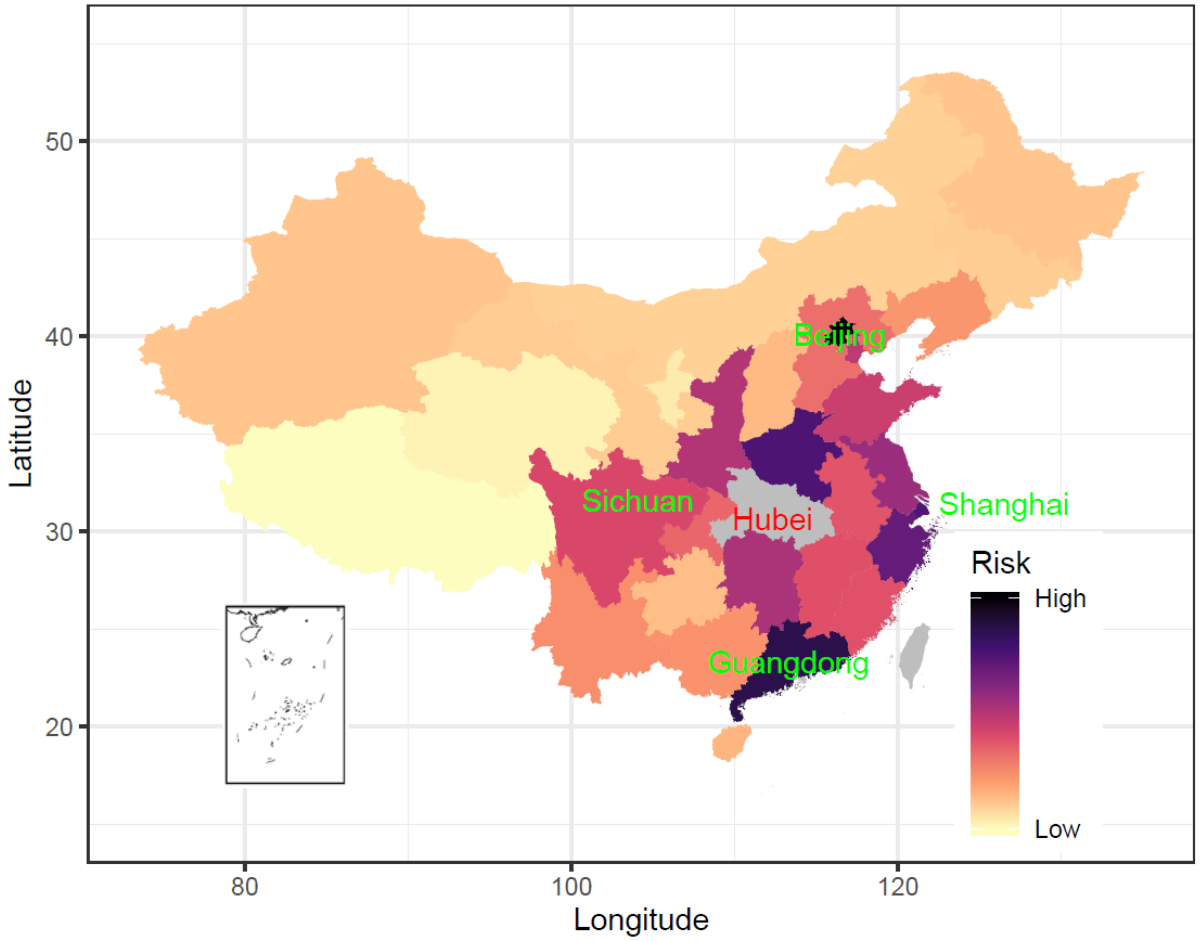

Figure 3. Risk of provinces in mainland China receiving travellers with 2019-nCoV infections from Wuhan during the Lunar New Year migration.

The risk of importation at provincial level was preliminarily defined as the percentage of travellers received by each province out of the total volume of travellers leaving Wuhan within 2 weeks before and since the first day of Lunar New Year, based on the population movement data from Baidu, Inc.

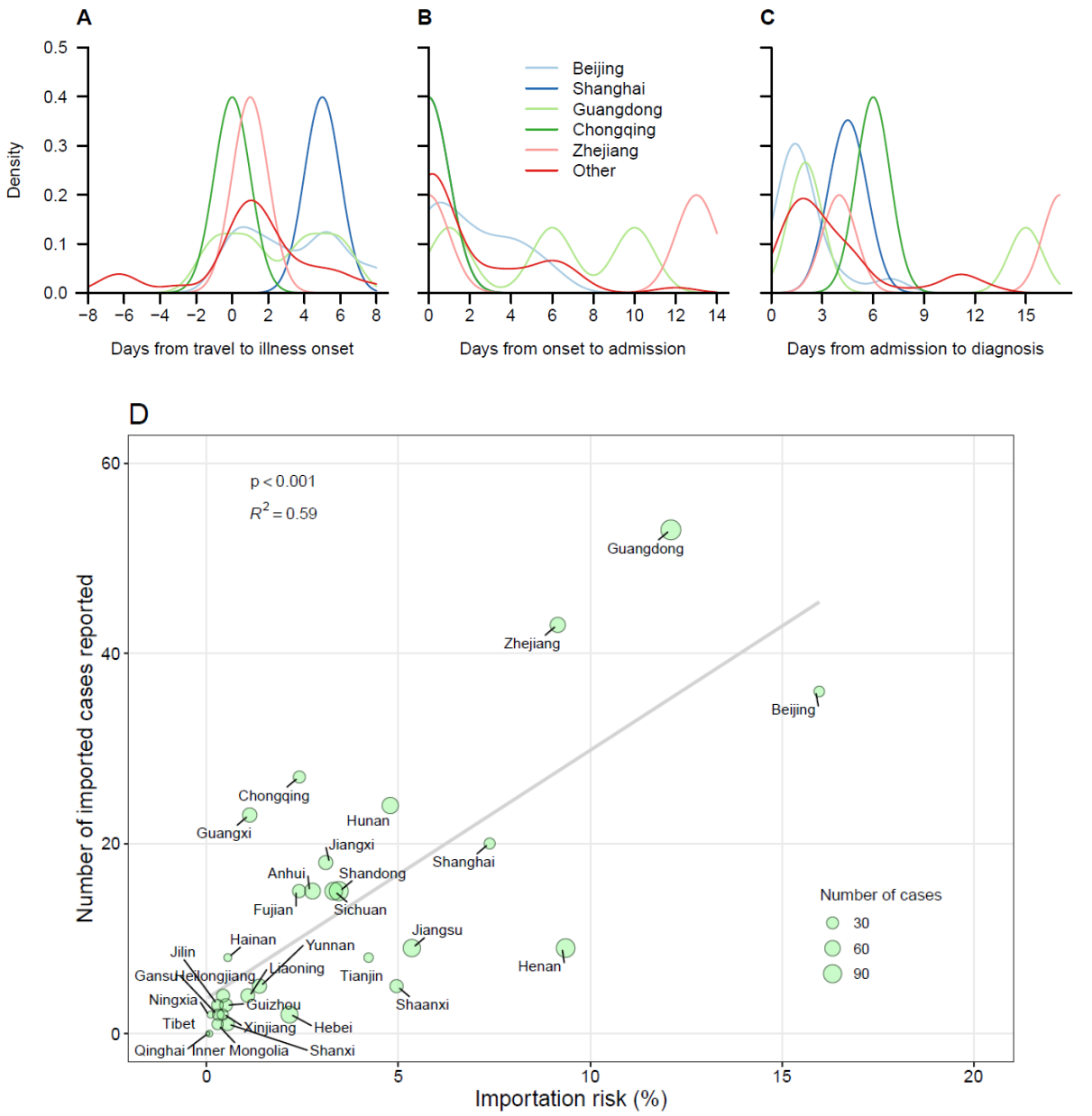

Figure 4. Time distributions of imported cases and correlation between the number of imported cases and the risk of importation via travellers from Wuhan within the two weeks before Lunar New Year's Day.

(A)-(C) The time distribution of imported cases travelling from Wuhan, illness onset, admission to hospital, and diagnosis by province. (D) correlation between the number of imported cases reported in each province and the risk of importation via travellers. The risk of importation at provincial level was preliminarily defined as the percentage of travellers received by each province out of the total volume of travellers leaving Wuhan within 2 weeks before and since the first day of Lunar New Year, based on the population movement data from Baidu, Inc. The data on cases as of January 24th, 2020, were obtained from the websites of Chinese National and Local Health Commissions.

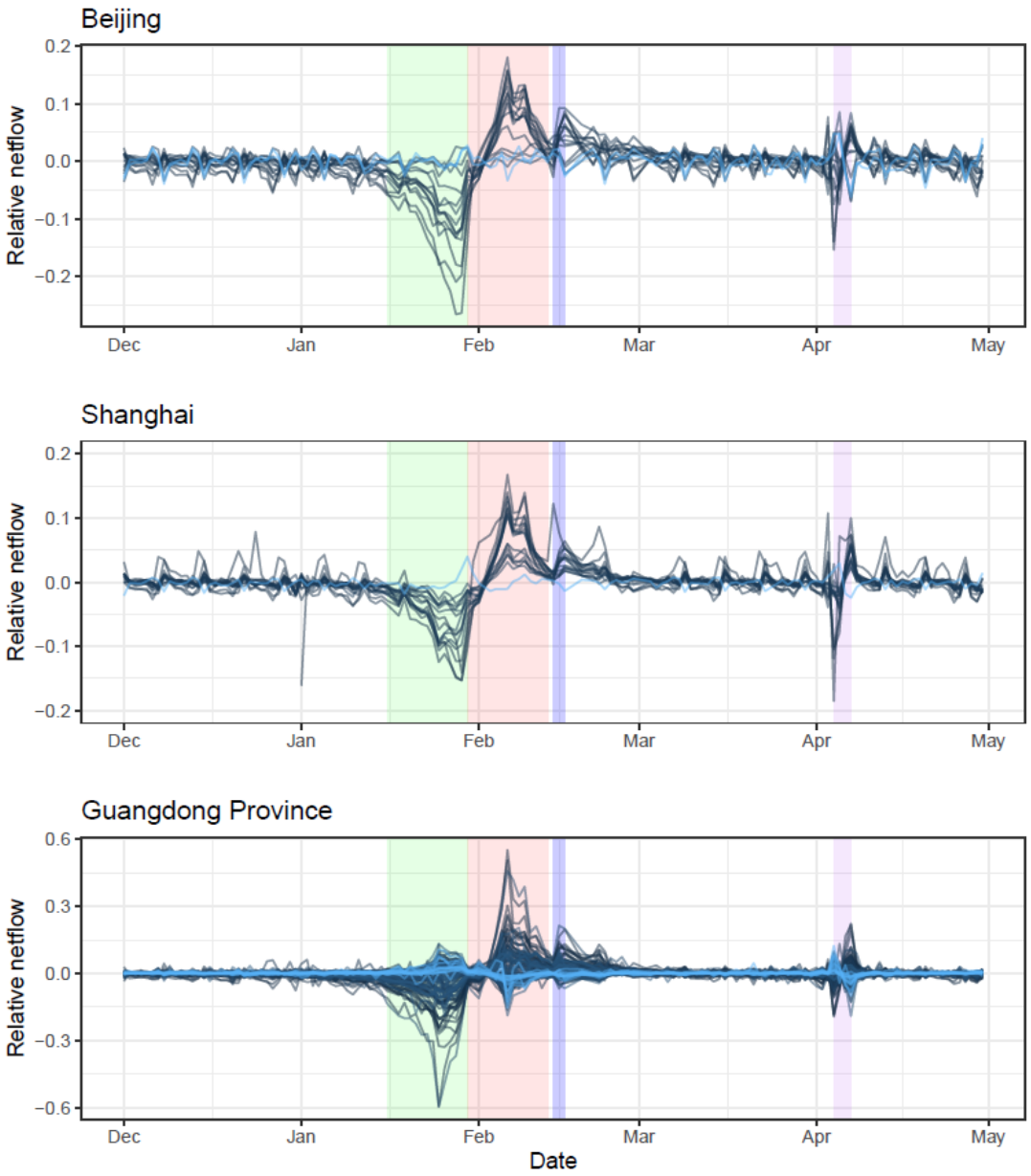

Figure 5. Patterns of daily human movement by county in Beijing, Shanghai, and Guangdong Province across six months.

Shadow colours:

- Green: 2 weeks before Lunar New Year;
- Red: 2 weeks since Lunar New Year;
- Purple: Lantern Festival;
- Pink: Tomb Sweeping Day

Relative netflow = (Inflow – Outflow)/population, based on the population movement data in 2013-2014 from Baidu, Inc.

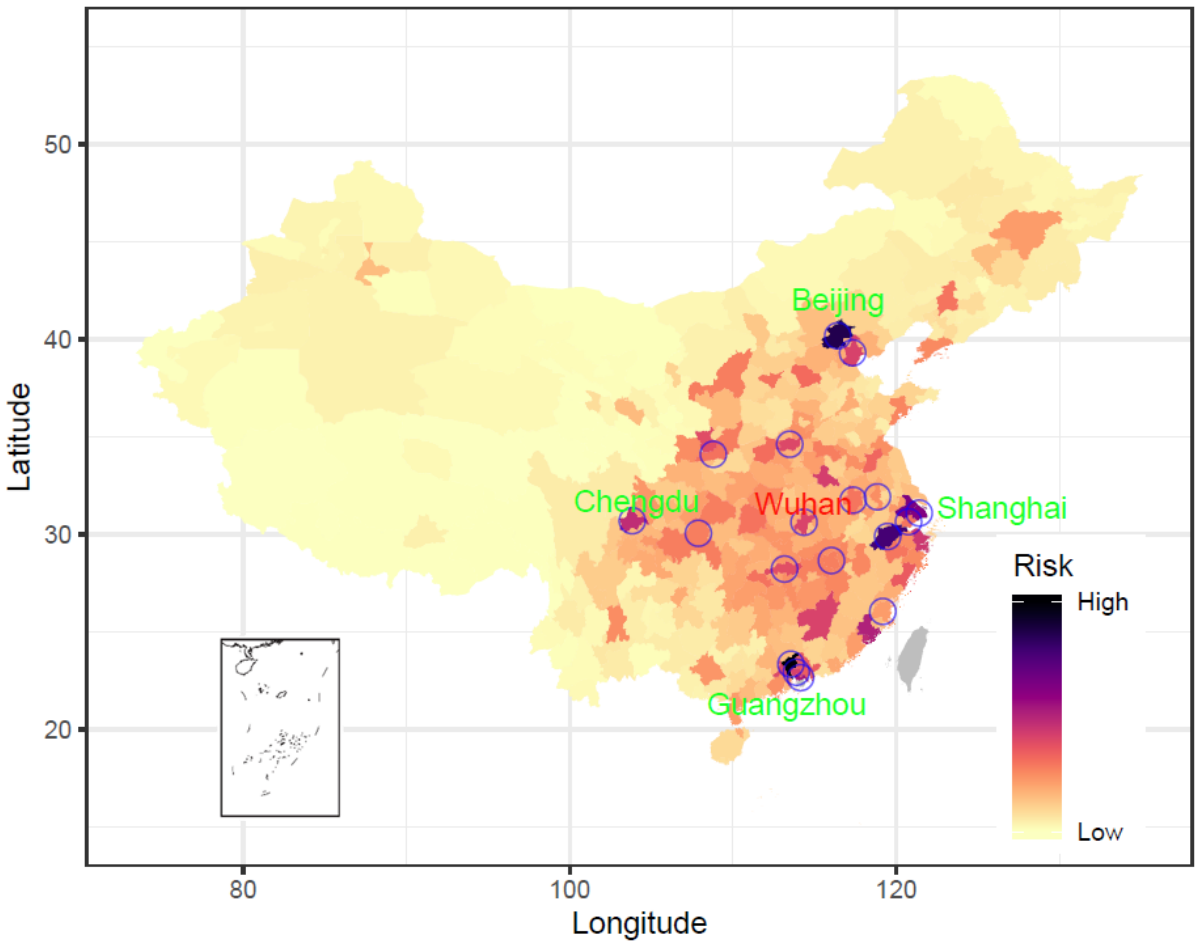

Figure 6. Risk of cities in mainland China receiving travellers from 18 high-risk cities (blue circles) with 2019-nCoV infections or importations during the next four weeks since Lunar New Year's Day.

The risk of importation at city level was preliminarily defined as the averaged percentage of travellers received by each city out of the total volume of travellers leaving each high-risk city, based on the population movement data from Baidu, Inc.

18 high-risk cities include Wuhan and other 17 cities in other provinces receiving high volume of travellers from Wuhan before the Lunar New Year: Beijing, Shanghai, Guangzhou, Zhengzhou, Tianjin, Hangzhou, Jiaxing, Changsha, Xi'an, Nanjing, Shenzhen, Chongqing, Nanchang, Chengdu, Hefei, Fuzhou, Dongguan.

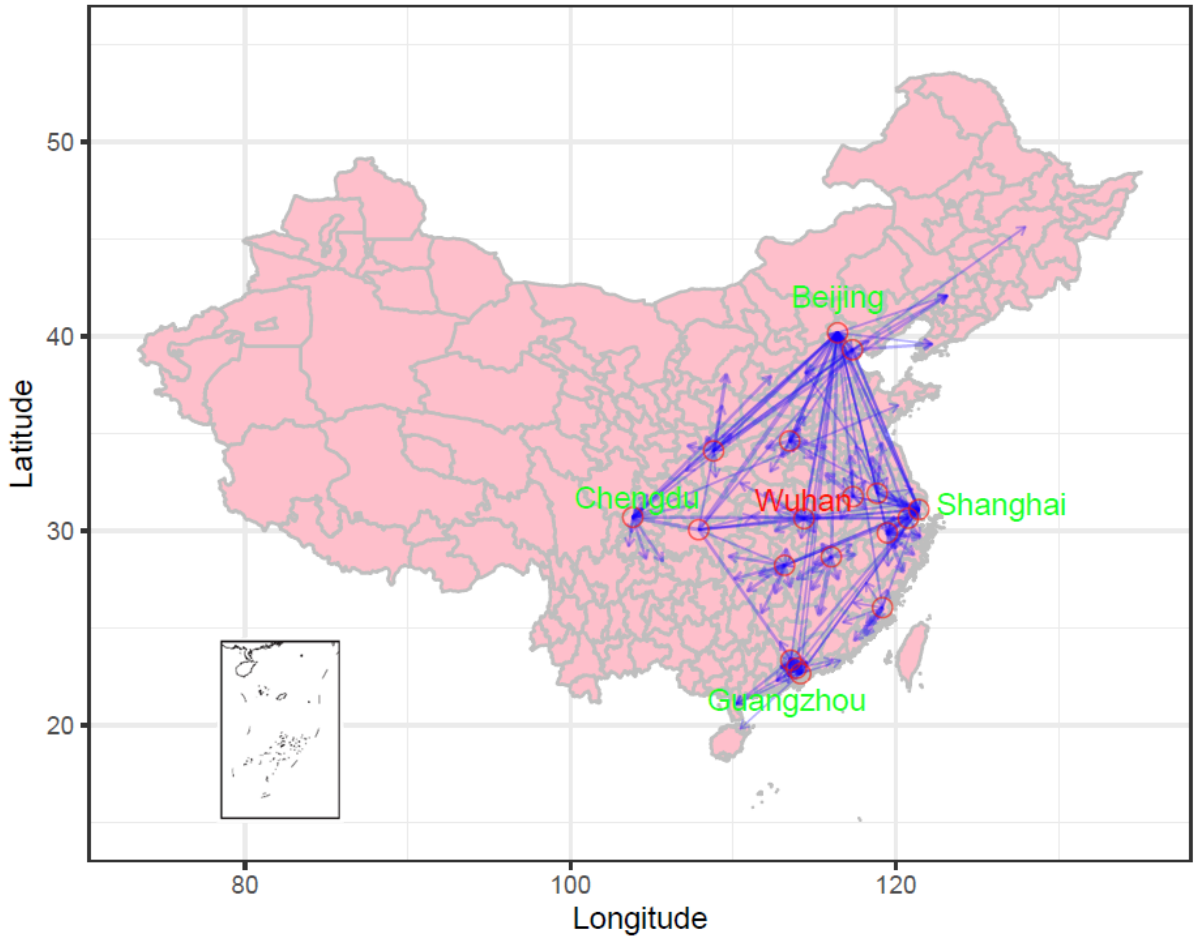

Figure 7. Estimated connectivity of cities in mainland China receiving travellers from 18 high-risk cities (blue circles) with 2019-nCoV infections or importations during the four weeks following Lunar New Year's Day.

The arrows show the link and direction of the risk of importation at city level, preliminarily defined as the percentage of travellers received by each city (top 10 ranked cities) out of the total volume of travellers leaving each high-risk city (18 cities), based on the population movement data from Baidu, Inc.

18 high-risk cities: Wuhan in Wuhan Province and 17 cities (Beijing, Shanghai, Guangzhou, Zhengzhou, Tianjin, Hangzhou, Jiaxing, Changsha, Xi'an, Nanjing, Shenzhen, Chongqing, Nanchang, Chengdu, Hefei, Fuzhou, Dongguan) in other provinces receiving high volume of travellers from Wuhan before the Lunar New Year.

Section II. International Travel

Table 4. Top 30 ranked cities across the globe receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day.

Rank	City	Country/region	Volume (in thousands)	Risk (%)*
1	Bangkok	Thailand	1062.9	7.86
2	Hong Kong	Hong Kong SAR, China	1001.7	7.41
3	Taipei	Taiwan, China	857.5	6.34
4	Seoul	South Korea	757.9	5.61
5	Tokyo	Japan	714.3	5.28
6	Singapore	Singapore	568.1	4.20
7	Phuket	Thailand	492.8	3.65
8	Osaka	Japan	434.1	3.21
9	Kuala Lumpur	Malaysia	382.7	2.83
10	Macau	Macau SAR, China	260.4	1.93
11	Denpasar Bali	Indonesia	222.2	1.64
12	Sydney	Australia	207.4	1.53
13	Chiang Mai	Thailand	156.9	1.16
14	Melbourne	Australia	154.5	1.14
15	Los Angeles	United States	154.5	1.14
16	New York	United States	145.9	1.08
17	Dubai	United Arab Emirates	144.9	1.07
18	Nha Trang	Viet Nam	143	1.06
19	London	United Kingdom	142.1	1.05
20	Ho Chi Minh City	Viet Nam	142	1.05
21	Nagoya	Japan	140.1	1.04
22	Kota Kinabalu	Malaysia	130.4	0.96
23	Phnom Penh	Cambodia	127.5	0.94
24	Krabi	Thailand	125.2	0.93
25	Manila	Philippines	121.9	0.90
26	Siem Reap	Cambodia	121.4	0.90
27	Paris	France	119.5	0.88
28	Jakarta	Indonesia	113.9	0.84
29	Kaohsiung	Taiwan	107.6	0.80
30	Frankfurt	Germany	103.3	0.76
	Other		4158.2	30.77
	Total		13514.9	100

*Relative risk was preliminary defined as the percentage of airline travellers received by each city out of the total volume of travellers leaving high-risk cities (18 cities), based on air

travel data from February to April 2018, obtained from the International Air Travel Association (IATA).The Lunar New Year in 2018 started from February 16th, 2018.

Table 5. Top 30 ranked countries or regions receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day.

Rank	Country/region	Volume (in thousands)	Risk *
1	Thailand	2031.9	15.03
2	Japan	1563.3	11.57
3	Hong Kong SAR, China	1001.7	7.41
4	Taiwan, China	979.7	7.25
5	South Korea	936.6	6.93
6	United States	773.3	5.72
7	Malaysia	634.3	4.69
8	Singapore	568.1	4.20
9	Viet Nam	468.4	3.47
10	Australia	455.6	3.37
11	Indonesia	412.5	3.05
12	Cambodia	262.9	1.95
13	Macao SAR, China	260.4	1.93
14	Philippines	250.3	1.85
15	Germany	234.9	1.74
16	Canada	208.5	1.54
17	United Kingdom	190.7	1.41
18	United Arab Emirates	162.3	1.20
19	Italy	152.9	1.13
20	Russia	151.3	1.12
21	France	137.9	1.02
22	New Zealand	120.7	0.89
23	India	106.7	0.79
24	Spain	105.8	0.78
25	Turkey	66.5	0.49
26	Egypt	57.5	0.43
27	Sri Lanka	55.7	0.41
28	Maldives	50.7	0.37
29	Netherlands	44.9	0.33
30	Myanmar	43.3	0.32
	Other	1025.6	7.59
	Total	13514.9	100

*Relative risk was preliminary defined as the percentage of airline travellers received by each city out of the total volume of travellers leaving high-risk cities (18 cities), based on air travel data from February to April 2018, obtained from the International Air Travel Association (IATA). The Lunar New Year in 2018 started from February 16th, 2018.

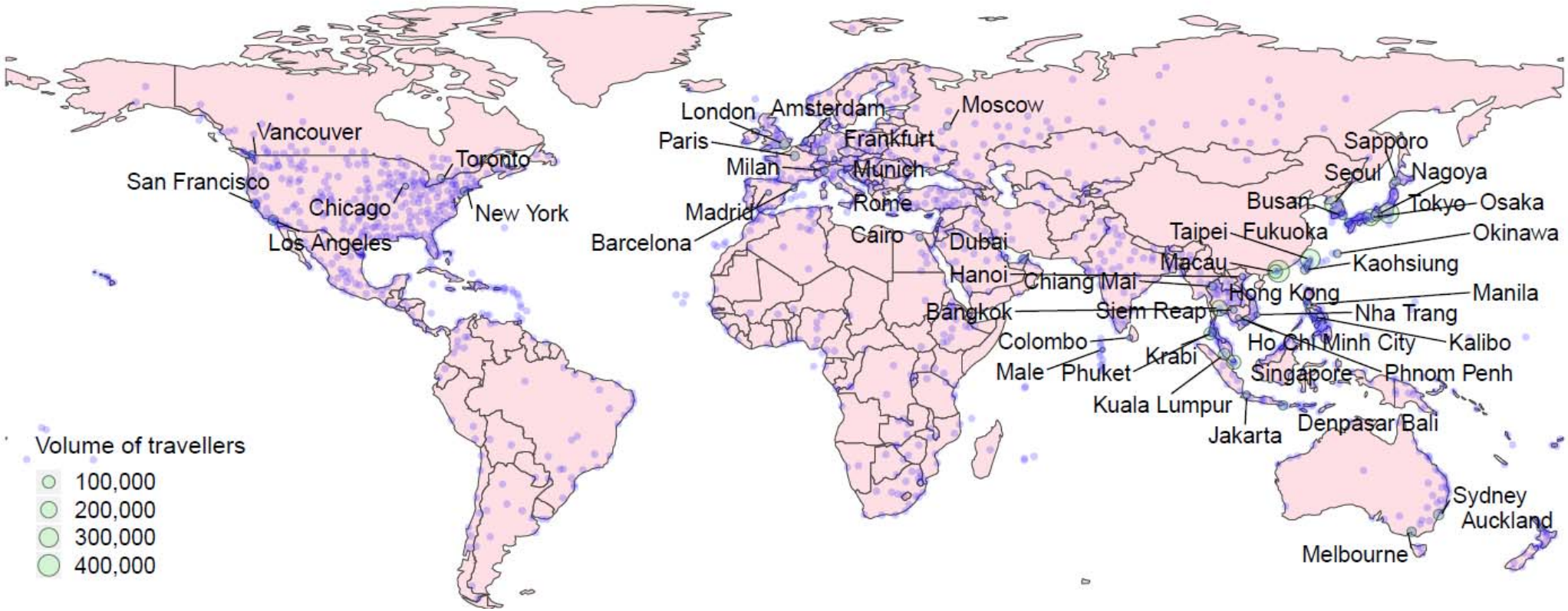

Figure 8. Geographic distribution of cities across the globe receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day. The volume of airline travellers of the top 30 ranked cities is presented.

Based on air travel data from February to April 2018, obtained from the International Air Travel Association (IATA). The Lunar New Year in 2018 started from February 16th, 2018.

Table 6. Top 30 ranked cities in Africa receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day.

Rank	City	Country/region	Volume	%*
1	Cairo	Egypt	56735	20.49
2	Johannesburg	South Africa	20530	7.42
3	Mauritius	Mauritius	18297	6.61
4	Addis Ababa	Ethiopia	17882	6.46
5	Casablanca	Morocco	15787	5.70
6	Nairobi	Kenya	12859	4.64
7	Entebbe	Uganda	8246	2.98
8	Accra	Ghana	8211	2.97
9	Lagos	Nigeria	8087	2.92
10	Lusaka	Zambia	7672	2.77
11	Dar Es Salaam	Tanzania	6769	2.44
12	Algiers	Algeria	6074	2.19
13	Luanda	Angola	5994	2.16
14	Khartoum	Sudan	5412	1.95
15	Abuja	Nigeria	4193	1.51
16	Lubumbashi	Congo (Kinshasa)	3546	1.28
17	Abidjan	Cote D'Ivoire	3511	1.27
18	Cape Town	South Africa	3461	1.25
19	Conakry	Guinea	3455	1.25
20	Tunis	Tunisia	2912	1.05
21	Libreville	Gabon	2786	1.01
22	Harare	Zimbabwe	2665	0.96
23	Dakar	Senegal	2659	0.96
24	Maputo	Mozambique	2560	0.92
25	Antananarivo	Madagascar	2515	0.91
26	Nouakchott	Mauritania	1955	0.71
27	Malabo	Equatorial Guinea	1864	0.67
28	Mahe Island	Seychelles	1850	0.67
29	Durban	South Africa	1815	0.66
30	Ndola	Zambia	1796	0.65

*The percentage of airline travellers received by each city in Africa out of the total volume of travellers leaving high-risk cities (18 cities) into Africa, based on air travel data from February to April 2018, obtained from the International Air Travel Association (IATA). The Lunar New Year in 2018 started from February 16th, 2018.

Table 7. African countries or territories receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day.

Rank	Country/region	Volume	%*	Rank	Country/region	Volume	%*
1	Egypt	57516	20.77	27	Seychelles	1863	0.67
2	South Africa	26405	9.54	28	Botswana	1627	0.59
3	Ethiopia	18393	6.64	29	Djibouti	1602	0.58
4	Mauritius	18297	6.61	30	Mali	1587	0.57
5	Morocco	16974	6.13	31	Congo (Brazzaville)	1500	0.54
6	Nigeria	13734	4.96	32	Chad	1425	0.51
7	Kenya	13185	4.76	33	Rwanda	1386	0.50
8	Zambia	9471	3.42	34	Sierra Leone	1330	0.48
9	Tanzania	8388	3.03	35	Namibia	1207	0.44
10	Uganda	8246	2.98	36	Malawi	1139	0.41
11	Ghana	8211	2.97	37	Benin	890	0.32
12	Algeria	7887	2.85	38	Togo	858	0.31
13	Angola	5994	2.16	39	Lesotho	853	0.31
14	Sudan	5433	1.96	40	Reunion	809	0.29
15	Congo (Kinshasa)	5248	1.90	41	Niger	790	0.29
16	Mozambique	3928	1.42	42	Liberia	711	0.26
17	Cote D'Ivoire	3511	1.27	43	South Sudan	711	0.26
18	Guinea	3455	1.25	44	Burkina Faso	406	0.15
19	Tunisia	2912	1.05	45	Gambia	365	0.13
20	Gabon	2786	1.01	46	Central African Rep	339	0.12
21	Cameroon	2734	0.99	47	Cape Verde	276	0.10
22	Zimbabwe	2716	0.98	48	Eritrea	246	0.09
23	Senegal	2659	0.96	49	Burundi	232	0.08
24	Madagascar	2515	0.91	50	Comoros	178	0.06
25	Mauritania	1955	0.71	51	Somalia	68	0.02
26	Equatorial Guinea	1864	0.67	52	Guinea-Bissau	52	0.02

*The percentage of airline travellers received by each city in Africa out of the total volume of travellers leaving high-risk cities (18 cities) into Africa, based on air travel data from February to April 2018, obtained from the International Air Travel Association (IATA).The Lunar New Year in 2018 started from February 16th, 2018.

Figure 9. Geographic distribution of African cities receiving airline travellers from 18 high-risk cities (Figure 6) in mainland China over a period of three months, representing 15 days before Lunar New Year's Day and 2 and half months following Lunar New Year's Day.

Based on air travel data from February to April 2018, obtained from the International Air Travel Association (IATA). The Lunar New Year in 2018 started from February 16th, 2018.

About WorldPop

WorldPop (www.worldpop.org) at the University of Southampton works to ensure that everyone is mapped and counted in decision making. Initiated in 2005, WorldPop develops geospatial integration methods for the production of spatially detailed demographic datasets in resource poor settings, with academic peer-review and publication of outputs. The group is a producer of open spatial demographic datasets used by governments, international agencies, academia, NGOs and the private sector. Close collaboration with UN agencies and national statistical offices in low/middle income countries is a primary focus, ensuring that research approaches are designed to maximise uptake and impact, with local capacity strengthening a priority.

Major focus areas for development and implementation cover population distributions, demographics and dynamics in resource-poor settings. The integration of traditional demographic datasets from censuses and surveys with satellite, cellphone and other spatial datasets is undertaken in geostatistical modelling frameworks. Outputs include high resolution maps of population counts, age/sex structures, births, pregnancies, poverty, reproductive, maternal and newborn health indicators, access to services, and vaccination coverage, among other metrics. Moreover, modelling frameworks for the development of population mobility maps, subnational migration flows, urban change and disease spread are developed.

WorldPop is made up of 30+ members of staff, including demographers, geographers, ecologists, statisticians, epidemiologists and computer scientists. Principal funders and collaborators include the Bill and Melinda Gates Foundation, UK Department for International Development, the World Bank, the Wellcome Trust, UNFPA, UNICEF, WHO and the Clinton Health Access Initiative.