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Risk for Transportation of Coronavirus Disease from Wuhan to Other Cities in China

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On January 23, 2020, China quarantined Wuhan to contain coronavirus disease (COVID-19). We estimated the probability of transportation of COVID-19 from Wuhan to 369 other cities in China before the quarantine. Expected COVID-19 risk is >50% in 130 (95% CI 89–190) cities and >99% in the 4 largest metropolitan areas.

In December 2019, a novel coronavirus, since named severe acute respiratory syndrome coronavirus 2, emerged in Wuhan, China (1), causing a respiratory illness that the World Health Organization has named coronavirus disease (COVID-19). On January 30, 2020, the World Health Organization declared the outbreak a public health emergency of international concern (2). By January 31, 2020, a total of 192 fatalities and 3,215 laboratory-confirmed cases had been reported in Wuhan; 8,576 additional cases were spread across >300 cities in mainland China, and 127 exported cases were reported in 23 countries spanning Asia, Europe, Oceania, and North America. The rapid global expansion, rising fatalities, unknown animal reservoir, and evidence of person-to-person transmission potential (3,4) initially resembled the 2003 SARS epidemic and raised concerns about global spread.

On January 22, 2020, China announced a travel quarantine of Wuhan and by January 30 expanded the radius to include 16 cities, encompassing a population of 45 million. At the time of the quarantine, China was already 2 weeks into the 40-day Spring Festival, during which residents and visitors make several billion trips throughout China to celebrate

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the Lunar New Year (5). Considering the timing of exported COVID-2019 cases reported outside of China, we estimate that only 8.95% (95% credibility interval [CrI] 2.22%–28.72%) of persons infected in Wuhan by January 12 might have had COVID-19 confirmed by January 22. By limiting our estimate to infections occurring ≥10 days before the quarantine, we account for an ≈5–6-day incubation period and 4–5 days between symptom onset and case detection (Appendix, https://wwwnc.cdc.gov/EID/article/26/5/20-0146-App1.pdf) (2–4,6). The low detection rate coupled with an average lag of 10 days between infection and detection (7) suggest that newly infected persons who traveled out of Wuhan just before the quarantine might have remained infectious and undetected in dozens of cities in China for days to weeks. Moreover, these silent importations already might have seeded sustained outbreaks that were not immediately apparent.

We estimated the probability of transportation of infectious COVID cases from Wuhan to cities throughout China before January 23 by using a simple model of exponential growth coupled with a stochastic model of human mobility among 369 cities in China (Appendix). Given that ≈98% of all trips taken during this period were made by train or car,

Figure. Risks for transportation of coronavirus disease (COVID-19) from Wuhan, China, before a quarantine was imposed on January 23, 2020. A) Daily travel volume to and from Wuhan, given as a percentage of the Wuhan population. Gray shading indicates the start of Spring Festival season on January 10, 2020, a peak travel period in China. B) Estimated and reported daily prevalence of COVID-19 in Wuhan. The green line and shading indicate model estimates of cumulative cases since December 1, 2019, with 95% credible interval bounds, assuming an epidemic doubling time of 7.31 days (95% credible interval 6.26–9.66 days). Black dots indicate cumulative confirmed case counts during January 1–22, 2020 (10). Gray shading at right indicates the start of Spring Festival season. C) Probability that ≥1 COVID-19 case infected in Wuhan traveled to cities in China by January 22, 2020. The 131 cities with a risk threshold >50% are indicated in shades of orange; 239 cities below that threshold are indicated in shades of blue. Map generated by using Mapbox (https://www.mapbox.com).
our analysis of air, rail, and road travel data yields more granular risk estimates than possible with air passenger data alone (8).

By fitting our epidemiologic model to data on the first 19 cases reported outside of China, we estimate an epidemic doubling time of 7.31 days (95% CrI 6.26–9.66 days) and a cumulative total of 12,400 (95% CrI 3,112–58,465) infections in Wuhan by January 22 (Appendix). Both estimates are consistent with a similar epidemiologic analysis of the first 425 cases confirmed in Wuhan (4). Assuming these rates of early epidemic growth, we estimate that 130 cities in China have a >50% chance of having a COVID case imported from Wuhan in the 3 weeks preceding the quarantine (Figure). By January 26, a total of 107 of these 130 high-risk cities had reported cases. However, 23 had not, including 5 cities with importation probabilities >99% and populations >2 million: Bazhong, Fushun, Laibin, Ziyang, and Chuxiong.

Under our lower bound estimate of 6.26 days for the doubling time, 190/369 cities lie above the 50% threshold for importation. Our risk assessment identified several cities throughout China likely to be harboring yet undetected cases of COVID-19 a week after the quarantine, suggesting that early 2020 ground and rail travel seeded cases far beyond the Wuhan region under quarantine.

Our conclusions are based on several key assumptions. To design our mobility model, we used data from Tencent (https://heat.qq.com), a major social media company that hosts applications including WeChat (=1.13 billion active users in 2019) and QQ (=808 million active users in 2019) (Statista, https://www.statista.com); consequently, our model might be demographically biased by the Tencent user base. Further, considerable uncertainty regarding the lag between infection and case detection remains. Our assumption of a 10-day lag is based on early estimates for the incubation period of COVID-19 (4) and prior estimates of the lag between symptom onset and detection for SARS (9). We expect that estimates for the doubling time and incidence of COVID-19 will improve as reconstructed linelists and more granular epidemiologic data become available (Appendix). However, our key qualitative insights likely are robust to these uncertainties, including extensive prequarantine exportations throughout China and far greater case counts in Wuhan than those reported before the quarantine.

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Code for estimating epidemiological parameters and probabilities of case introductions, as well as aggregate mobility data, are available from GitHub (https://github.com/linwangidd/2019nCoV_EID). Aggregate data also are available (Appendix Table 3). Additional code and data requests should be addressed to L.A.M. (laurenmeyers@austin.utexas.edu).

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In January 2020, we investigated a 2-family cluster of persons infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the city of Wuhan in Hubei Province. The initial 2 cases of SARS-CoV-2 infection (coronavirus disease [COVID-19]) in Zhoushan were diagnosed in 2 teachers (persons A and D) from the same department at a college that had sponsored an academic conference on January 5, 2020. A 45-year-old teacher from Wuhan (person W) arrived on January 5 for the conference and joined persons A and D on January 6 for dinner, where they ate from common serving plates. After returning to Wuhan on January 7, person W experienced the onset of fever, cough, sore throat, and malaise on January 8. He visited a local hospital where, according to the patient’s self-report, he was confirmed to have COVID-19 by a local office of the Chinese CDC. For person A and D, the only known potential exposures for SARS-CoV-2 were their dinner and conference attendance with person W (Figure).

On January 10, person A (a 29-year-old man) experienced the onset of fever, cough, and skin tingling and went to a local hospital for treatment. Laboratory tests at the hospital indicated leukopenia, and a real-time reverse transcription PCR (rRT-PCR) test for influenza A and B viruses was negative. The patient was given an antipyretic and some traditional medicines commonly used in China. After 3 days, his fever subsided, but his cough persisted. On January 15, the patient went to a different hospital, where routine blood test results were unremarkable but a chest radiograph revealed bilateral invasive lesions. He was prescribed amoxicillin and levofloxacin for 3 days. Because his cough did not improve, he was hospitalized for further evaluation. When the treating physician learned that the patient had had contact with a visitor from Wuhan before symptom onset, a throat swab specimen was sent for rRT-PCR testing for SARS-CoV-2 (1). On January 19, SARS-CoV-2 infection was confirmed at the laboratory of the Zhoushan CDC.

Person A lived with his 28-year-old wife (person B) and his 21-year-old sister (person C). The 2 women were confined at home for 14 days starting on the day of person A’s hospital admission. Because of their 10 days of contact with person A after his fever onset, their respiratory specimens were collected on January 20 by Zhoushan CDC staff for
Risk for Transportation of 2019 Novel Coronavirus Disease from Wuhan to Other Cities in China

Appendix

Data

We analyzed the daily number of passengers traveling between Wuhan and 369 other cities in mainland China. We obtained mobility data from the location-based services of Tencent (https://heat.qq.com). Users permit Tencent to collect their realtime location information when they install applications, such as WeChat (≈1.13 billion active users in 2019) and QQ (≈808 million active users in 2019), and Tencent Map. By using the geolocation of users over time, Tencent reconstructed anonymized origin–destination mobility matrices by mode of transportation (air, road, and train) between 370 cities in China, including 368 cities in mainland China and the Special Administrative Regions of Hong Kong and Macau. The data are anonymized and include 28 million trips to and 32 million trips from Wuhan, during December 3, 2016–January 24, 2017. We estimated daily travel volume during the 7 weeks preceding the Wuhan quarantine, December 1, 2019–January 22, 2020, by aligning the dates of the Lunar New Year, resulting in a 3-day shift. To infer the number of new infections in Wuhan per day during December 1, 2019–January 22, 2020, we used the mean daily number of passengers traveling to the top 27 foreign destinations from Wuhan during 2018–2019, which were provided in other recent studies (1–3).

Model

We considered a simple hierarchical model to describe the dynamics of 2019 novel coronavirus disease (COVID-19) infections, detections, and spread.
Epidemiologic Model

By using epidemiologic evidence from the first 425 cases of COVID-19 confirmed in Wuhan by January 22, 2020 (4), we made the following assumptions regarding the number of new cases, $dI_\omega(t)$, infected in Wuhan per day, $t$.

- The COVID-19 epidemic was growing exponentially during December 1, 2019–January 22, 2020, as determined by the following:
  
  $$dI_\omega(t) = i_0 \times \exp(\lambda \times t)$$

  in which $i_0$ denotes the number of initial cases on December 1, 2019 (5), and $\lambda$ denotes the epidemic growth rate during December 1, 2019–January 22, 2020.

- After infection, new cases were detected with a delay of $D = 10$ days (6), which comprises an incubation period of 5–6 days (4,7–11) and a delay from symptom onset to detection of 4–5 days (12,13). During this 10-day interval, we labeled cases as infected. Given the uncertainty in these estimates, we also performed the estimates by assuming a shorter delay ($D = 6$ days) and a longer delay ($D = 14$ days) between infection and case detection (Appendix Table 2).

Our model can be improved by incorporating the probability distribution for the delay between infection and detection, as reconstructed line lists (14–17) and more granular epidemiologic data are becoming available.

Under these assumptions, we calculated the number of infectious cases at time, $t$, by the following:

$$I_\omega(t) = \int_{u = t - D}^{t} dI_\omega(u)du$$

The prevalence of infectious cases is given by the following:

$$\xi(t) = \frac{I_\omega(t)}{N_\omega}$$

in which $N_\omega = 11.08$ million, the population of Wuhan.
Mobility Model

We assumed that visitors to Wuhan have the same daily risk for infection as residents of Wuhan and constructed a nonhomogenous Poisson process model (18–20) to estimate the risk for exportation of COVID-19 by residents of and travelers to Wuhan. In this model, $W_{j,t}$ denotes the number of residents of Wuhan that travel to city $j$ on day $t$ and $M_{j,t}$ denotes the number of travelers from city $j$ traveling to Wuhan on day $t$. Then, the rate at which infected residents of Wuhan travel to city $j$ at time $t$ is given as $\gamma_{j,t} = \xi(t) \times W_{j,t}$ and the rate at which travelers from city $j$ get infected in Wuhan and return to their home city while still infected is $\Psi_{j,t} = \xi(t) \times M_{j,t}$. This model assumes that newly infected visitors to Wuhan will return to their home city while still infectious. By using this model, the probability of introducing $\geq 1$ case of COVID-19 from Wuhan to city $j$ by time $t$ is given by

$$1 - \exp\left[-\int_{u = t_0}^{t} (\gamma_{j,u} + \Psi_{j,u}) du\right]$$

in which $t_0$ denotes the beginning of the study period, December 1, 2019.

Inference of Epidemic Parameters

We applied a likelihood-based method to estimate our model parameters, including the number of initial cases $i_0$ and the epidemic growth rate $\lambda$, from the arrival times of the 19 reported cases transported from Wuhan to 11 cities outside of China, as of January 22, 2020 (Appendix Table 1). All 19 cases were Wuhan residents. We aggregated all other cities without cases reported by January 22, 2020 into a single location ($j = 0$).

In this model, $N_j$ denotes the number of infected residents of Wuhan who were detected in location $j$ outside of China, and $\chi_{j,i}$ denotes the time at which the $i$-th COVID-19 case was detected in a Wuhan resident in location $j$; $\chi_{j,0}$ denotes the time at which international surveillance for infected travelers from Wuhan began, January 1, 2020 (21); and $E$ denotes the end of the study period on January 22, 2020. As indicated above, the rate at which infected residents of Wuhan arrive at location $j$ at time $t$ is $\gamma_{j,t}$. Then the log-likelihood for all 19 cases reported outside of China by January 22, 2020 is given by:
which yields the following log-likelihood function:

\[
\sum_{j=1}^{11} \sum_{i=1}^{N_j} \log(\gamma_{j,i}) - \frac{\sum_{j=0}^{11} W_{j,i}}{N_\omega} \times \frac{i_0}{\lambda^2} \times \left[ \exp(\lambda \times E) - \exp(\lambda \times \chi_{j,0}) + \exp(\lambda \times (\chi_{j,0} - D)) - \exp(\lambda \times (E - D)) \right]
\]

**Parameter Estimation**

We directly estimated the number of initial cases, \(i_0\), on December 1, 2019, and the epidemic growth rate, \(\lambda\), during December 1, 2019–January 22, 2020. We infer the epidemic parameters in a Bayesian framework by using the Markov Chain Monte Carlo (MCMC) method with Hamiltonian Monte Carlo sampling and noninformative flat prior. From these, we derive the doubling time of incident cases as \(d_T = \log(2)/\lambda\) and the cumulative number of cases and of reported cases by January 22, 2020. We also derived the basic reproduction number, by assuming a susceptible-exposed-infectious-recovery (SEIR) model for COVID-19 in which the incubation period is exponentially distributed with mean \(L\) in the range of 3–6 days and the infectious period is also exponentially distributed with mean \(Z\) in the range of 2–7 days. The reproduction number is then given by \(R_0 = (1 + \lambda \times L) \times (1 + \lambda \times Z)\).

We estimated the case detection rate in Wuhan by taking the ratio between the number of reported cases in Wuhan by January 22, 2020 and our estimates for the number of infections occurring \(\geq 10\) days prior (i.e., by January 12, 2020). We truncated our estimate 10 days before the quarantine to account for the estimated time between infection and case detection, assuming a 5–6 day incubation period (4,7–11) followed by 4–5 days between symptom onset and case detection (12,13). Given the uncertainty in these estimates, we also provide estimates assuming shorter and longer delays in the lag between infection and case reporting (Appendix Table 3).
We ran 10 chains in parallel. Trace plot and diagnosis confirmed the convergence of MCMC chains with posterior median and 95% CrI estimates as follows:

- **Epidemic growth rate, $\lambda$:** 0.095 (95% CrI 0.072–0.111), corresponding to an epidemic doubling time of incident cases of 7.31 (95% CrI 6.26–9.66) days;
- **Number of initial cases in Wuhan on December 1, 2019:** 7.78 (95% CrI 5.09–18.27);
- **Basic reproductive number, $R_0$:** 1.90 (95% CrI 1.47–2.59);
- **Cumulative number of infections in Wuhan by January 22, 2020:** 12,400 (95% CrI 3,112–58,465);
- **Case detection rate by January 22, 2020:** 8.95% (95% CrI 2.22%–28.72%). This represents the ratio between the 425 confirmed cases in Wuhan during this period (22) and our estimate that 4,747 (95% CrI 1,480–19,151) cumulative infections occurred by January 12, 2020 (i.e., $\geq$10 days before the quarantine to account for the typical lag between infection and case detection).

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**Appendix Table 1. Cases of 2019 novel coronavirus detected outside of China**

| Country          | City    | Date, 2020 |
|------------------|---------|------------|
| Thailand         | Bangkok | Jan 8      |
| Thailand         | Bangkok | Jan 17     |
| Thailand         | Bangkok | Jan 19     |
| Thailand         | Bangkok | Jan 21     |
| Thailand         | Chiang Mai | Jan 21   |
| Nepal            | Kathmandu | Jan 9    |
| Vietnam          | Hanoi   | Jan 13     |
| United States    | Chicago | Jan 13     |
| United States    | Seattle | Jan 15     |
| Singapore        |        | Jan 21     |
| Korea            | Seoul   | Jan 19     |
| Korea            | Seoul   | Jan 22     |
| Japan            | Tokyo   | Jan 18     |
| Japan            | Tokyo   | Jan 19     |
| Taiwan           | Taipei  | Jan 20     |
| Taiwan           | Taipei  | Jan 21     |
| Taiwan           | Taipei  | Jan 21     |
| Australia        | Sydney  | Jan 18     |
| Australia        | Sydney  | Jan 20     |

*As of January 22, 2020.*
Appendix Table 2. Sensitivity analysis for the delay between infection and case confirmation, assuming that cases were confirmed either 6 d, 10 d (baseline), or 14 d after infection

| Delay (D) from infection to case reporting | Posterior median (95% CrI) |
|------------------------------------------|---------------------------|
| **D = 6 d**                              |                           |
| Epidemic doubling time, d                | 6.79 (5.88–8.64)          |
| Initial number of cases on December 1, 2019, \(i_0\) | 7.95 (5.10–18.43)         |
| Basic reproduction number, \(R_0\)       | 1.98 (1.54–2.71)          |
| Cumulative cases by January 22, 2020     | 17.376 (4.410–80.915)     |
| Cumulative cases by January 16, 2020 (\(D = 6 d\) before January 22, 2020) | 9.362 (2.696–39.705) |
| Reporting rate through January 22, 2020  | 4.54% (1.07%–15.8%)       |
| **D = 10 d**                             |                           |
| Epidemic doubling time, d                | 7.31 (6.26–9.66)          |
| Initial number of cases on December 1, 2019, \(i_0\) | 7.78 (5.09–18.27)         |
| Basic reproduction number, \(R_0\)       | 1.90 (1.47–2.59)          |
| Cumulative cases by January 22, 2020     | 12.400 (3.112–58.465)     |
| Cumulative cases by January 16, 2020 (\(D = 6 d\) before January 22, 2020) | 4.747 (1.480–19.151) |
| Reporting rate through January 22, 2020  | 8.95% (2.22%–28.72%)      |
| **D = 14 d**                             |                           |
| Epidemic doubling time, d                | 7.64 (6.49–10.36)         |
| Initial number of cases on December 1, 2019, \(i_0\) | 7.62 (5.09–18.13)         |
| Basic reproduction number, \(R_0\)       | 1.86 (1.44–2.52)          |
| Cumulative cases by January 22, 2020     | 10.229 (2.564–48.681)     |
| Cumulative cases by January 16, 2020 (\(D = 6 d\) before January 22, 2020) | 2.805 (957–10,758)   |
| Reporting rate through January 22, 2020  | 15.15% (3.95%–44.41%)     |

Appendix Table 3. Mobility between Wuhan and 369 cities in China during December 3, 2016–January 24, 2017*

| ID | City     | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|----------|-------------|------------|----------|---------------------------|
| 1  | Xiaogan  | 9,646,286   | 5,333,682  | 4,312,604 | 4.90                      |
| 2  | Huanggang| 7,786,732   | 4,436,928  | 3,349,804 | 6.32                      |
| 3  | Xianning | 3,987,334   | 2,149,524  | 1,837,810 | 2.53                      |
| 4  | Beijing  | 3,921,153   | 1,956,195  | 1,964,958 | 1.07                      |
| 5  | Ezhou    | 3,858,883   | 1,508,938  | 2,349,945 | 21.73                     |
| 6  | Jingzhou | 3,439,123   | 2,216,479  | 1,222,644 | 5.70                      |
| 7  | Xiangyang| 3,160,473   | 1,959,413  | 1,201,060 | 5.64                      |
| 8  | Huangshi | 2,787,922   | 1,521,685  | 1,266,237 | 2.47                      |
| 9  | Guangzhou| 2,555,286   | 705,205    | 1,850,081 | 14.04                     |
| 10 | Yichang  | 2,266,974   | 1,420,349  | 846,625   | 4.13                      |
| 11 | Shenzhen | 1,675,478   | 188,316    | 1,487,162 | 11.91                     |
| 12 | Suizhou  | 1,536,742   | 934,564    | 602,176   | 2.20                      |
| 13 | Xiantao  | 1,492,596   | 856,578    | 636,018   | 1.15                      |
| 14 | Shiyian  | 1,252,190   | 897,666    | 354,524   | 3.41                      |
| 15 | Chongqing| 1,177,096   | 720,442    | 456,654   | 30.48                     |
| 16 | Enshi    | 869,910     | 610,937    | 258,973   | 4.56                      |
| 17 | Tianmen  | 716,794     | 447,408    | 269,386   | 1.29                      |
| 18 | Changsha | 644,273     | 318,784    | 325,489   | 7.65                      |
| 19 | Shanghai | 571,458     | 72,150     | 499,308   | 24.2                      |
| 20 | Xinyang  | 564,841     | 338,180    | 226,661   | 6.44                      |
| 21 | Qianjiang| 489,747     | 288,200    | 201,547   | 0.96                      |
| 22 | Jingmen  | 408,465     | 269,703    | 138,762   | 2.90                      |
| 23 | Yueyang  | 352,512     | 185,672    | 166,840   | 5.68                      |
| 24 | Zhumadian| 316,181     | 214,425    | 101,756   | 6.99                      |
| 25 | Nanchang | 301,903     | 123,239    | 178,664   | 5.37                      |
| 26 | Jiujiang | 229,539     | 106,873    | 122,666   | 4.85                      |
| 27 | Baoding  | 205,124     | 126,334    | 78,790    | 11.63                     |
| 28 | Nanyang  | 173,653     | 127,666    | 45,987    | 10.07                     |
| 29 | Hengyang | 155,591     | 32,443     | 123,148   | 7.29                      |
| 30 | Luode    | 153,329     | 103,153    | 50,184    | 2.64                      |
| 31 | Sanya    | 151,726     | 29,147     | 122,579   | 0.75                      |
| 32 | Lijiang  | 121,699     | 33,825     | 87,844    | 1.29                      |
| 33 | Dazhou   | 120,983     | 120,983    | 0         | 5.60                      |
| 34 | Luan     | 117,242     | 53,698     | 63,544    | 4.77                      |
| 35 | Qingyuan | 116,218     | 35,704     | 80,514    | 3.85                      |
| 36 | Chengdu  | 113,983     | 50,532     | 63,406    | 15.92                     |
| 37 | Kunming  | 108,452     | 46,613     | 61,839    | 6.73                      |
| 38 | Chenzhou | 102,565     | 18,274     | 84,291    | 4.71                      |
| 39 | Guilin   | 100,723     | 92,078     | 8,645     | 5.01                      |
| ID | City          | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|---------------|-------------|------------|----------|--------------------------|
| 40 | Shaoguan      | 94,847      | 11,483     | 83,364   | 2.96                     |
| 41 | Shijiazhuang  | 93,102      | 70,128     | 22,974   | 10.78                    |
| 42 | Ankang        | 81,065      | 81,065     | 0        | 2.66                     |
| 43 | Xining        | 73,246      | 54,707     | 18,539   | 5.74                     |
| 44 | Shennongjia   | 66,818      | 37,240     | 29,578   | 0.08                     |
| 45 | Suining       | 64,847      | 43,223     | 21,624   | 3.30                     |
| 46 | Haikou        | 64,774      | 30,848     | 33,926   | 2.24                     |
| 47 | Shenyang      | 64,258      | 33,663     | 30,595   | 8.29                     |
| 48 | Hanzhong      | 58,082      | 58,074     | 8        | 3.45                     |
| 49 | Anyang        | 57,825      | 38,146     | 19,679   | 5.13                     |
| 50 | Dongguan      | 57,672      | 44,125     | 13,547   | 8.26                     |
| 51 | Liuzhou       | 56,640      | 43,180     | 13,460   | 3.96                     |
| 52 | Handan        | 53,890      | 27,321     | 26,569   | 4.02                     |
| 53 | Ankang        | 52,175      | 42,872     | 9,303    | 9.49                     |
| 54 | Xinxiang      | 50,264      | 11,069     | 39,195   | 7.57                     |
| 55 | Shennongjia   | 48,697      | 36,007     | 12,690   | 2.55                     |
| 56 | NanNing       | 47,505      | 33,242     | 14,263   | 7.06                     |
| 57 | Xingtai       | 44,627      | 33,727     | 10,900   | 7.32                     |
| 58 | Xuchang       | 44,397      | 41,839     | 2,558    | 4.38                     |
| 59 | Anqing        | 41,590      | 17,398     | 24,192   | 4.61                     |
| 60 | Dali          | 40,710      | 17,524     | 23,186   | 3.56                     |
| 61 | Yangzhou      | 40,510      | 40,530     | 0        | 5.47                     |
| 62 | Xiamen        | 40,039      | 14,993     | 25,046   | 9.32                     |
| 63 | Qingdao       | 36,803      | 21,919     | 14,884   | 9.20                     |
| 64 | Nanchong      | 33,778      | 33,764     | 14       | 6.40                     |
| 65 | Pingdingshan  | 30,833      | 25,945     | 4,888    | 4.98                     |
| 66 | Tieling       | 30,807      | 13,535     | 17,272   | 2.65                     |
| 67 | Putian        | 30,488      | 21,972     | 8,516    | 2.89                     |
| 68 | Zhumai        | 30,263      | 20,698     | 9,565    | 1.68                     |
| 69 | Wenzhou       | 29,609      | 15,634     | 13,975   | 9.18                     |
| 70 | Jiaozuo       | 26,455      | 26,445     | 10       | 3.55                     |
| 71 | Guangan       | 25,597      | 24,288     | 1,309    | 3.26                     |
| 72 | Nantong       | 22,577      | 7,753      | 14,824   | 7.30                     |
| 73 | Xiantan       | 22,283      | 7,879      | 14,404   | 2.84                     |
| 74 | Langfang      | 21,900      | 7,301      | 14,599   | 4.62                     |
| 75 | Tianjin       | 21,343      | 12,018     | 9,325    | 15.62                    |
| 76 | Zhenjiang     | 21,284      | 17,469     | 3,815    | 3.18                     |
| 77 | Suzhou2       | 20,366      | 0          | 20,366   | 10.65                    |
| 78 | Huluaduo      | 19,114      | 18,044     | 1,070    | 2.55                     |
| 79 | Jincheng      | 18,326      | 18,318     | 8        | 2.32                     |
| 80 | Siping        | 17,782      | 3,610      | 14,172   | 3.20                     |
| 81 | Dalian        | 17,190      | 6,147      | 11,043   | 6.99                     |
| 82 | Zhongshan     | 17,181      | 14,989     | 2,192    | 3.23                     |
| 83 | Shangluo      | 17,007      | 16,740     | 263      | 3.37                     |
| 84 | Beihai        | 16,142      | 6,120      | 10,022   | 1.64                     |
| 85 | Changzhi      | 14,729      | 14,729     | 0        | 3.44                     |
| 86 | Bazhong       | 14,705      | 14,705     | 0        | 3.31                     |
| 87 | Hebi          | 14,173      | 9,224      | 4,949    | 1.61                     |
| 88 | Xishuangbanna | 11,767      | 6,146      | 5,621    | 1.17                     |
| 89 | Hong Kong     | 11,453      | 5,823      | 5,630    | 7.45                     |
| 90 | Zhoukou       | 11,264      | 11,066     | 0        | 8.82                     |
| 91 | Urumqi        | 10,893      | 10,058     | 835      | 3.52                     |
| 92 | Harbin        | 10,110      | 5,991      | 4,119    | 10.98                    |
| 93 | Ningbo        | 9,964       | 5,272      | 4,692    | 7.88                     |
| 94 | Weinan        | 9,743       | 9,743      | 0        | 5.37                     |
| 95 | Changchun     | 9,379       | 6,040      | 3,339    | 7.51                     |
| 96 | Laibin        | 9,200       | 8,652      | 548      | 2.20                     |
| 97 | Panjin        | 9,137       | 8,398      | 732      | 1.44                     |
| 98 | Xiangxi       | 8,616       | 2,506      | 6,110    | 2.64                     |
| 99 | City of Yantai| 8,223       | 4,390      | 3,833    | 7.06                     |
|100 | Yuxi          | 7,895       | 5,513      | 2,382    | 2.38                     |
|101 | Tangshan      | 7,604       | 7,152      | 452      | 7.84                     |
|102 | Lingshui      | 7,477       | 1,792      | 5,685    | 0.36                     |
|103 | Xining        | 7,414       | 5,460      | 1,954    | 2.33                     |
|104 | Liyang        | 7,291       | 7,291      | 0        | 3.63                     |
|105 | Hezhou        | 7,274       | 7,274      | 0        | 2.04                     |
|106 | Hangzhou      | 7,112       | 797        | 6,315    | 9.19                     |
|107 | Nanping       | 7,053       | 3,854      | 3,199    | 2.66                     |
| ID | City     | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|----------|-------------|------------|----------|--------------------------|
| 108| Yinchuan | 6,789       | 3,364      | 3,425    | 2.08                     |
| 109| Changzhou| 6,761       | 6,761      | 0        | 4.71                     |
| 110| Zigong   | 6,705       | 6,681      | 24       | 2.78                     |
| 111| Fushun   | 6,576       | 5,816      | 760      | 2.07                     |
| 112| Puer     | 6,335       | 3,781      | 2,554    | 2.62                     |
| 113| Taizhou2 | 6,269       | 2,362      | 3,907    | 6.08                     |
| 114| Changde  | 6,131       | 4,946      | 1,185    | 5.84                     |
| 115| Jinzhou  | 6,016       | 5,919      | 115      | 3.06                     |
| 116| Chengde  | 5,937       | 5,786      | 151      | 3.53                     |
| 117| Yangzhou | 5,840       | 5,840      | 0        | 4.49                     |
| 118| Qujing   | 5,396       | 5,041      | 355      | 6.08                     |
| 119| Yangquan | 5,313       | 5,269      | 44       | 1.40                     |
| 120| Anshan   | 5,308       | 4,044      | 1,264    | 3.61                     |
| 121| Guiyang  | 5,183       | 3,207      | 1,976    | 4.70                     |
| 122| Zhangjiag | 5,137      | 4,112      | 1,045    | 1.53                     |
| 123| Quanzhou | 5,127       | 1,705      | 3,422    | 8.58                     |
| 124| Jian     | 5,126       | 0          | 5,126    | 4.92                     |
| 125| Wuwei    | 4,965       | 4,679      | 286      | 1.82                     |
| 126| Ledong   | 4,807       | 3,014      | 1,793    | 0.53                     |
| 127| Liaoyang | 4,554       | 4,255      | 299      | 1.84                     |
| 128| Jiangmen | 4,550       | 4,439      | 111      | 4.54                     |
| 129| LanZhou  | 4,125       | 2,226      | 1,928    | 3.71                     |
| 130| Qinhuangdao | 4,147    | 3,883      | 264      | 3.09                     |
| 131| Ziyang   | 3,971       | 3,933      | 38       | 2.54                     |
| 132| Jingdezhen | 3,971     | 1,916      | 2,055    | 1.65                     |
| 133| Dqing    | 3,933       | 1,123      | 2,810    | 0.41                     |
| 134| Shengzhou| 3,871       | 1,134      | 2,737    | 0.96                     |
| 135| Dehong   | 3,645       | 1,735      | 1,910    | 1.29                     |
| 136| Panzhihua| 3,536       | 2,197      | 1,339    | 1.24                     |
| 137| Neijiang | 3,537       | 3,493      | 33       | 3.75                     |
| 138| Foshan   | 3,422       | 3,157      | 265      | 7.46                     |
| 139| Zhangjiang| 3,377      | 1,426      | 1,951    | 7.27                     |
| 140| Qionghai | 3,287       | 1,321      | 1,966    | 0.51                     |
| 141| Hohhot   | 3,278       | 2,905      | 373      | 3.09                     |
| 142| Luzhou   | 3,155       | 2,974      | 181      | 4.31                     |
| 143| Dandong  | 3,136       | 2,165      | 971      | 2.41                     |
| 144| Deyang   | 3,129       | 2,921      | 173      | 3.52                     |
| 145| Baoshan  | 3,114       | 1,767      | 1,347    | 2.61                     |
| 146| Fangchenggang | 2,967 | 1,486      | 1,481    | 0.93                     |
| 147| Chuxiong | 2,966       | 2,419      | 547      | 2.74                     |
| 148| Datong   | 2,881       | 1,914      | 967      | 3.42                     |
| 149| Zunyi    | 2,775       | 1,544      | 1,231    | 6.23                     |
| 150| Jilin    | 2,464       | 1,031      | 1,433    | 4.24                     |
| 151| Haidong  | 2,451       | 1,062      | 1,359    | 1.45                     |
| 152| Baolou   | 2,378       | 1,947      | 431      | 2.86                     |
| 153| Chengmai County | 2,301   | 905        | 1,396    | 0.59                     |
| 154| Huangshan| 2,226       | 959        | 1,267    | 1.38                     |
| 155| Benxi    | 2,166       | 1,886      | 280      | 1.71                     |
| 156| Wenchang | 2,087       | 1,124      | 963      | 0.56                     |
| 157| Liupanshui| 2,086     | 589        | 1,497    | 2.91                     |
| 158| Lingao County | 2,085   | 1,349      | 736      | 0.52                     |
| 159| Daqing   | 2,062       | 715        | 1,347    | 2.76                     |
| 160| Bozhou   | 2,031       | 1,014      | 1,017    | 0.48                     |
| 161| Honghe   | 1,960       | 1,262      | 698      | 4.68                     |
| 162| Lincang  | 1,901       | 927        | 974      | 2.52                     |
| 163| Yancheng | 1,855       | 790        | 1,065    | 7.24                     |
| 164| Shan Tou | 1,847       | 786        | 1,061    | 5.58                     |
| 165| Fuzhou3  | 1,865       | 1,846      | 0        | 4.00                     |
| 166| Zhangjiakou | 1,845     | 1,743      | 102      | 4.43                     |
| 167| Yiyang   | 1,820       | 1,365      | 455      | 4.43                     |
| 168| Dongying | 1,794       | 1,624      | 170      | 2.13                     |
| 169| Tonghua  | 1,792       | 749        | 1,043    | 2.17                     |
| 170| Jiyang   | 1,765       | 940        | 825      | 6.09                     |
| 171| Dongfang | 1,759       | 894        | 865      | 0.44                     |
| 172| Huizhou  | 1,725       | 1,694      | 51       | 4.78                     |
| 173| Weihai   | 1,744       | 677        | 1,067    | 2.82                     |
| 174| Wanning  | 1,741       | 792        | 949      | 0.57                     |
| 175| Jiyuan   | 1,555       | 1,461      | 94       | 0.73                     |
| ID | City       | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|------------|-------------|------------|----------|---------------------------|
| 176| Longyan    | 1,535       | 508        | 1,027    | 2.63                      |
| 177| Changjiang | 1,535       | 953        | 582      | 0.23                      |
| 178| Zhoushan   | 1,474       | 796        | 678      | 1.16                      |
| 179| Xinyu      | 1,471       | 0          | 1,471    | 1.17                      |
| 180| Nyingchi   | 1,448       | 260        | 1,188    | 0.20                      |
| 181| Weifang    | 1,372       | 930        | 442      | 9.36                      |
| 182| Qianxinan  | 1,371       | 514        | 857      | 2.84                      |
| 183| Baishan    | 1,234       | 674        | 567      | 1.20                      |
| 184| Changi     | 1,326       | 744        | 582      | 1.60                      |
| 185| Chongzuo   | 1,203       | 777        | 426      | 2.07                      |
| 186| Changdu    | 1,181       | 369        | 812      | 0.68                      |
| 187| Baoting    | 1,168       | 460        | 708      | 0.17                      |
| 188| Hotan      | 1,146       | 671        | 475      | 2.14                      |
| 189| Linfen     | 1,118       | 793        | 325      | 4.46                      |
| 190| Tunchang County | 1,090   | 489        | 601      | 0.27                      |
| 191| Qitahei    | 1,087       | 569        | 518      | 0.87                      |
| 192| Fuxin      | 1,065       | 823        | 242      | 1.78                      |
| 193| Zhangzhou  | 980         | 335        | 645      | 5.05                      |
| 194| Yulin4     | 967         | 461        | 506      | 5.76                      |
| 195| Shihezi    | 945         | 802        | 143      | 0.60                      |
| 196| Matsubara  | 930         | 330        | 600      | 2.78                      |
| 197| Jixi       | 928         | 553        | 370      | 1.84                      |
| 198| Qinzhou    | 902         | 491        | 411      | 3.24                      |
| 199| Hailai     | 900         | 577        | 323      | 0.28                      |
| 200| Tongren    | 893         | 893        | 0        | 3.14                      |
| 201| Dingan County | 882    | 494        | 388      | 0.29                      |
| 202| Altay      | 824         | 446        | 378      | 0.62                      |
| 203| Chaoyang   | 806         | 429        | 377      | 0.11                      |
| 204| Wuzhishan  | 779         | 192        | 587      | 1.18                      |
| 205| Karasay    | 760         | 382        | 368      | 0.42                      |
| 206| Chaoyang   | 750         | 704        | 46       | 2.95                      |
| 207| Baise Ganzi | 722     | 402        | 320      | 3.62                      |
| 208| Nuijiang   | 720         | 377        | 343      | 0.54                      |
| 209| Aral       | 711         | 365        | 346      | 0.33                      |
| 210| Tower      | 705         | 481        | 224      | 1.35                      |
| 211| Wuzhong    | 705         | 429        | 276      | 1.39                      |
| 212| Yingkou    | 704         | 348        | 356      | 2.44                      |
| 213| Ningde     | 690         | 446        | 244      | 2.89                      |
| 214| Shizuishan | 672         | 481        | 191      | 0.80                      |
| 215| Ordos      | 630         | 458        | 172      | 2.06                      |
| 216| Ximeng     | 629         | 458        | 171      | 1.00                      |
| 217| Shuangyashan | 609    | 185        | 424      | 1.46                      |
| 218| Leshan     | 585         | 313        | 272      | 3.27                      |
| 219| Hainan     | 584         | 253        | 332      | 0.46                      |
| 220| Baiyin     | 583         | 262        | 321      | 1.72                      |
| 221| Chaozhou   | 570         | 230        | 340      | 2.65                      |
| 222| Haixi      | 566         | 458        | 108      | 0.52                      |
| 223| Chifeng    | 552         | 487        | 65       | 4.31                      |
| 224| Yantian    | 522         | 379        | 143      | 2.10                      |
| 225| Yanan      | 520         | 492        | 28       | 2.25                      |
| 226| Liaoyuan   | 513         | 352        | 160      | 1.18                      |
| 227| Wenshan    | 500         | 282        | 218      | 3.62                      |
| 228| Yili       | 496         | 419        | 77       | 4.62                      |
| 229| Shannan    | 494         | 212        | 282      | 0.34                      |
| 230| Rizhao     | 485         | 326        | 159      | 2.90                      |
| 231| Maoming    | 480         | 172        | 308      | 6.12                      |
| 232| Ganzhong   | 479         | 287        | 192      | 0.23                      |
| 233| Guigang    | 475         | 261        | 214      | 4.33                      |
| 234| Shuozhou   | 455         | 249        | 206      | 1.77                      |
| 235| Baisha     | 451         | 262        | 189      | 0.12                      |
| 236| Xian       | 450         | 450        | 0        | 8.83                      |
| 237| Meishan    | 446         | 219        | 227      | 3.00                      |
| 238| Xingan League | 439   | 91         | 348      | 1.60                      |
| 239| Wulanchabu | 434         | 332        | 102      | 2.11                      |
| 240| Bayannaoer | 424         | 275        | 148      | 1.68                      |
| 241| Mianyang   | 398         | 288        | 110      | 4.81                      |
| 242| Shigatse   | 397         | 288        | 109      | 0.72                      |
| 243| Alxa League| 389         | 286        | 103      | 0.25                      |
| ID | City       | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|------------|-------------|------------|----------|--------------------------|
| 244| Aksu       | 373         | 202        | 171      | 2.46                     |
| 245| Wuhai      | 369         | 230        | 139      | 0.56                     |
| 246| Tongliao   | 367         | 201        | 166      | 3.12                     |
| 247| Wujiaqu    | 357         | 103        | 254      | 0.09                     |
| 248| Bazhou     | 357         | 216        | 141      | 1.28                     |
| 249| Qiannan    | 348         | 299        | 49       | 3.26                     |
| 250| Yichun     | 332         | 29         | 303      | 1.10                     |
| 251| Ali        | 324         | 178        | 148      | 0.10                     |
| 252| Zhongwei   | 324         | 217        | 107      | 1.15                     |
| 253| Jiaxing    | 321         | 45         | 276      | 4.61                     |
| 254| Zhengzhou  | 319         | 83         | 236      | 9.72                     |
| 255| Huangnan   | 318         | 142        | 176      | 0.27                     |
| 256| Kashgar    | 309         | 177        | 132      | 4.21                     |
| 257| White      | 306         | 253        | 53       | 1.91                     |
| 258| Cangzhou   | 303         | 187        | 116      | 7.51                     |
| 259| Qingyang   | 294         | 256        | 38       | 2.24                     |
| 260| Bijie      | 265         | 227        | 38       | 6.64                     |
| 261| Anshun     | 261         | 206        | 55       | 2.33                     |
| 262| Zibo       | 241         | 134        | 107      | 4.69                     |
| 263| Jiuquan    | 233         | 144        | 91       | 1.12                     |
| 264| Nagqu      | 233         | 231        | 2        | 0.48                     |
| 265| Dingxi     | 227         | 128        | 99       | 2.79                     |
| 266| Hechi      | 220         | 107        | 113      | 3.50                     |
| 267| Chizhou    | 214         | 191        | 23       | 1.44                     |
| 268| Tumshuk    | 210         | 32         | 178      | 0.17                     |
| 269| Yangjiang  | 204         | 96         | 108      | 2.53                     |
| 270| Jinchang   | 203         | 147        | 56       | 0.47                     |
| 271| Liangshan  | 199         | 84         | 115      | 4.82                     |
| 272| Turpan     | 197         | 157        | 40       | 0.63                     |
| 273| Hulunbeir  | 196         | 151        | 45       | 2.53                     |
| 274| Jinchong   | 187         | 18         | 169      | 3.35                     |
| 275| Yaan       | 184         | 130        | 54       | 1.54                     |
| 276| Pingliang  | 175         | 129        | 46       | 2.10                     |
| 277| Golow      | 175         | 167        | 8        | 0.20                     |
| 278| Daxinganling | 158     | 45         | 113      | 0.44                     |
| 279| Yulin2     | 155         | 72         | 83       | 3.38                     |
| 280| Binzhou    | 148         | 69         | 77       | 3.89                     |
| 281| Zhaoqing   | 143         | 112        | 31       | 4.08                     |
| 282| Zhangye    | 143         | 52         | 91       | 1.22                     |
| 283| Qilhar     | 143         | 85         | 58       | 5.05                     |
| 284| Linxia     | 142         | 58         | 84       | 2.03                     |
| 285| Jiayuguan  | 130         | 55         | 75       | 0.25                     |
| 286| Lishui     | 127         | 41         | 86       | 2.17                     |
| 287| Suihua     | 127         | 81         | 40       | 5.21                     |
| 288| Guyuan     | 119         | 99         | 20       | 1.22                     |
| 289| Heyuan     | 110         | 37         | 73       | 3.08                     |
| 290| Mudanjiang | 110         | 59         | 51       | 2.63                     |
| 291| Wuzhou     | 108         | 61         | 47       | 3.02                     |
| 292| Kezhou     | 107         | 11         | 96       | 0.62                     |
| 293| Luliang    | 107         | 11         | 96       | 3.85                     |
| 294| Taiyuan    | 103         | 0          | 103      | 4.34                     |
| 295| Tianshui   | 101         | 82         | 19       | 3.32                     |
| 296| Heihe      | 99          | 38         | 61       | 1.64                     |
| 297| Yushu      | 94          | 87         | 7        | 0.41                     |
| 298| Baoji      | 94          | 94         | 0        | 3.78                     |
| 299| Laiwu      | 94          | 85         | 29       | 1.38                     |
| 300| Yunfu      | 93          | 44         | 49       | 2.48                     |
| 301| Yingtan    | 89          | 9          | 79       | 1.16                     |
| 302| Tongchuan  | 81          | 60         | 21       | 0.85                     |
| 303| Pingxiang  | 76          | 0          | 76       | 1.91                     |
| 304| Jiamusi    | 76          | 38         | 38       | 2.36                     |
| 305| Shaoxing   | 76          | 44         | 32       | 4.99                     |
| 306| Xinzhou    | 72          | 19         | 53       | 3.16                     |
| 307| Shanwei    | 70          | 43         | 27       | 3.04                     |
| 308| Dezhou     | 68          | 24         | 44       | 5.79                     |
| 309| Jinhua     | 63          | 0          | 63       | 5.52                     |
| 310| Meizhou    | 61          | 41         | 20       | 4.36                     |
| 311| Hami       | 61          | 31         | 30       | 0.61                     |

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| ID | City                      | Total trips | From Wuhan | To Wuhan | 2016 population, millions |
|----|--------------------------|-------------|------------|----------|--------------------------|
| 312| Lhasa                    | 60          | 60         | 0        | 0.60                     |
| 313| Yuncheng                 | 59          | 42         | 17       | 5.31                     |
| 314| Gannan                   | 51          | 26         | 25       | 0.71                     |
| 315| Liaocheng                | 36          | 0          | 36       | 6.04                     |
| 316| Zhaotong                 | 35          | 35         | 0        | 5.48                     |
| 317| Jinan                    | 30          | 30         | 0        | 7.23                     |
| 318| Guangyuan                | 28          | 19         | 9        | 2.64                     |
| 319| Hegang                   | 26          | 19         | 7        | 1.04                     |
| 320| Luoyang                  | 21          | 0          | 21       | 6.80                     |
| 321| Tongling                 | 18          | 0          | 18       | 1.60                     |
| 322| Chuzhou                  | 17          | 0          | 17       | 4.04                     |
| 323| Huzhou                   | 16          | 0          | 16       | 2.98                     |
| 324| Bozhou                   | 13          | 7          | 6        | 5.10                     |
| 325| Taian                    | 11          | 0          | 11       | 5.64                     |
| 326| Quzhou                   | 10          | 0          | 10       | 2.16                     |
| 327| Huaibei                  | 10          | 0          | 10       | 2.21                     |
| 328| Zaozhuang                | 9           | 0          | 9        | 3.92                     |
| 329| Huaihua                  | 8           | 0          | 8        | 4.92                     |
| 330| Bengbu                   | 7           | 0          | 7        | 3.33                     |
| 331| Huainan                  | 7           | 0          | 7        | 3.46                     |
| 332| Xuancheng                | 6           | 0          | 6        | 2.60                     |
| 333| Hengshui                 | 6           | 0          | 6        | 4.45                     |
| 334| Longnan                  | 6           | 0          | 6        | 2.60                     |
| 335| Hefei                    | 0           | 0          | 0        | 7.87                     |
| 336| Ganzhou                  | 0           | 0          | 0        | 8.59                     |
| 337| Shuanghe                 | 0           | 0          | 0        | 0.05                     |
| 338| Maanshan                 | 0           | 0          | 0        | 2.78                     |
| 339| Bazhou                   | 0           | 0          | 0        | 0.94                     |
| 340| Linyi                    | 0           | 0          | 0        | 10.44                    |
| 341| Beltun                   | 0           | 0          | 0        | 0.08                     |
| 342| Yibin                    | 0           | 0          | 0        | 4.51                     |
| 343| Shangxiu                 | 0           | 0          | 0        | 7.28                     |
| 344| Taizhou4                 | 0           | 0          | 0        | 4.65                     |
| 345| Shaoyang                 | 0           | 0          | 0        | 7.32                     |
| 346| Heze                     | 0           | 0          | 0        | 8.62                     |
| 347| Yichun                   | 0           | 0          | 0        | 5.53                     |
| 348| Wuxi                     | 0           | 0          | 0        | 6.53                     |
| 349| Fuyang                   | 0           | 0          | 0        | 7.99                     |
| 350| Yutian County, Xinjiang  | 0           | 0          | 0        | 0.22                     |
| 351| Xuzhou                   | 0           | 0          | 0        | 8.71                     |
| 352| Suqian                   | 0           | 0          | 0        | 4.88                     |
| 353| Hetian County, Xinjiang  | 0           | 0          | 0        | 0.28                     |
| 354| Huainan                  | 0           | 0          | 0        | 4.89                     |
| 355| Kaifeng                  | 0           | 0          | 0        | 4.55                     |
| 356| Nanjing                  | 0           | 0          | 0        | 8.27                     |
| 357| Loudi                    | 0           | 0          | 0        | 3.89                     |
| 358| Suzhou4                  | 0           | 0          | 0        | 5.6                      |
| 359| Macau                    | 0           | 0          | 0        | 0.63                     |
| 360| Jining                   | 0           | 0          | 0        | 8.35                     |
| 361| Qiandongnan              | 0           | 0          | 0        | 3.51                     |
| 362| Kokodala                 | 0           | 0          | 0        | 0.08                     |
| 363| Xianyang                 | 0           | 0          | 0        | 4.99                     |
| 364| Liangyang                | 0           | 0          | 0        | 4.5                      |
| 365| Gejiu, Yunnan            | 0           | 0          | 0        | 0.47                     |
| 366| Shangrao                 | 0           | 0          | 0        | 6.75                     |
| 367| Moyu County, Xinjiang    | 0           | 0          | 0        | 0.53                     |
| 368| Wuhu                     | 0           | 0          | 0        | 3.67                     |
| 369| Sanmenxia                | 0           | 0          | 0        | 2.56                     |

*Data derived from user geolocation data from Tencent (https://heat.qq.com). Cities are sorted according to the overall travel volume to and from Wuhan. These data also are available from github (https://github.com/ZhanweiDU/2019nCov.git).
Appendix Figure 1. The risk for introduction of 2019 novel coronavirus disease (COVID-19) from Wuhan to other cities in China before the January 23, 2020 quarantine of Wuhan. Lines indicate probabilities that at $\geq 1$ person infected with COVID-19 in Wuhan arrived in a listed city by the date indicated on the x-axis. The estimates were calculated by using mobility data collected from the location-based services of Tencent (https://heat.qq.com) during December 10, 2017–January 24, 2018, the timeframe that corresponds to the Spring Festival travel period of December 8, 2019–January 22, 2020. All cities with an expected importation probability $>10\%$ by January 22, 2020 ($n = 212$) are shown.
Appendix Figure 2. Uncertainty analysis representing the number of 2019 novel coronavirus disease (COVID-19) exposures in Wuhan per day. Lines show the probability that ≥1 transportation of COVID-19 infection occurred from Wuhan to Beijing, Guangzhou, Shenzhen, and Shanghai during December 8, 2020–January 22, 2020. Error bars indicate 95% credible intervals.

Appendix Figure 3. Risk for transportation of 2019 novel coronavirus disease (COVID-19) from Wuhan to 130 cities in China by January 23, 2020. All cities represented have mean importation probability >50%. As of January 26, 2020, 82.3% (107/130) of these cities had reported cases. Grey circles indicate cities that were included in the quarantine as of January 24, 2020. Red circles indicate cities outside the quarantine area with confirmed cases; blue circles indicate cities outside the quarantine area without confirmed cases as of January 26th, 2020.