Correlation between travellers departing from Wuhan before the Spring Festival and

subsequent spread of COVID-19 to all provinces in China

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Highlight:

We found a strong correlation between travel volumes departing from Wuhan, Hubei Province before the Spring Festival and the extent of amplification of the outbreak of COVID-19 in China in 2020, with 100 top cities. Almost 70% of exportations were within cities in Hubei province.

In December 2019, a cluster of pneumonia, now known as COVID-19, was reported in Wuhan, Hubei Province, in the central part of China. As of 9 March 2020, more than 80,700 COVID-19 cases have been reported in China. Wuhan was the epicentre. Wuhan is the capital city of Hubei Province, and is one of the well-developed cities in China. Wuhan is also a major transportation hub in China, as it is located on the crossroads between the railway line linking Beijing and Guangzhou and the Yangtze River linking Chongqing and Shanghai. In response to the rapid spread within Hubei Province and exportations to other countries[1], the Chinese government implemented a lock-down of Wuhan on 24 January, 2020, the day before Spring Festival. Population movement is high during Spring Festival with about 2.97 billion passengers travelling during the Spring Festival in 2019.[2] As Wuhan is a major transportation hub in China, it is estimated that about five million people left the city during the Spring Festival travel rush before Jan 24, 2020. The aim of this essay is to explore the correlation between travellers departing from Wuhan before the Spring Festival and the extent of amplification of the outbreak of COVID-19 in China.

The data referring to population mobility were collected from the Baidu Migration database (http://qianxi.baidu.com/), which is a non-profit project aimed to provide data on population mobility during the Chinese Spring Festival rush. The database is able to provide the overall proportion of travellers departing from one city during a certain period. According to the instructions of the database, the proportion of travellers departing from Wuhan to one city is calculated by n_1/n_2, where n_1 is defined as the number of travellers departing from Wuhan to one selected city during a certain period and n_2 is the total number of travellers departing from Wuhan during a certain period. For instance, the proportion of travellers departing from Wuhan to Beijing was 1%, if the number of travellers departing from Wuhan to Beijing was 50, 000 during a certain period and the total number of travellers departing from Wuhan was 5 million during the same period. We extracted data between Jan 10, 2020 and Jan 24, 2020, on travellers departing from Wuhan to other cities and calculated the proportions of travellers departing from Wuhan to the top 100 cities in China.

All confirmed cases of COVID-19 and persons recovered from COVID-19 in the top 100 cities were aggregated from official announcements by searching the publicly available sources. The deadline was at 11:59 p.m. Feb 11, 2020 (China standard time, CST). According to the official announcements, all cases were applied with the same diagnostic criteria based on the recommendation by the National Health Commission of China (http://www.nhc.gov.cn/). No ethical approval was needed for this study. The proportion of cases in a destination city was calculated by m_1/m_2, where m_1 is the number of confirmed cases found in one selected city and m_2 is that found in China outside of Wuhan. The recovery rate in each city was also recorded. Furthermore, considering several socioeconomic factors had a potential impact in the spreading of COVID-19, population, population density, regional income, and level of health care in the top 100 cities were extracted from the National Bureau of Statistics of China (http://data.stats.gov.cn/).

We used an analysis of correlation to evaluate the associations between the proportion of travellers departing from Wuhan and four indexes of the extent of amplification of the outbreak of COVID-19 in the top 100 cities. The proportions of travellers departing from Wuhan in the top 100 cities were not normally distributed. Thus, a Spearman correlation analysis was applied. Besides, the correlations between the socioeconomic factors and two indexes of the extent of amplification of the outbreak of COVID-19 were analyzed. In addition, we did the scatter plots and the regression curves. Considering the health system for COVID-19 in Hubei Province differs from that in other areas and the results may depend on data quality of district health systems, a subgroup analysis according the district health systems was performed. The data were analyzed by SPSS statistic 22.0 (SPSS Inc., Illinois, Chicago, USA). All statistical significance was defined as $P<0.05$.

COVID-19 cases in top 100 cities in China

Up to Feb 11, 2020, 44, 653 confirmed COVID-19 infections in China mainland with a total of 4740 recovered cases. Of these, a total of 25095 confirmed cases were reported in China outside of Wuhan. The top 100 cities are located in four municipalities (i.e. Beijing, Shanghai, Chongqing, Tianjin) and 16 provinces or autonomous regions in China. Overall, a total of 21807 cases (86.9%) were reported in the selected top 100 cities with 13798 cases (54.98%) in 15 cities in Hubei Province. There are 15 cities except Wuhan in Hubei Province. The hot spots of COVID-19 cases were the other 15 cities in Hubei

province and the cities in neighboring provinces including Henan, Hunan, Jiangxi, and Anhui. Meanwhile, several well-developed areas, such as Beijing, Shanghai, Guangdong Province, and Zhejiang Province also showed a high proportion of COVID-19 cases.

Comparisons between proportions of travellers departing from Wuhan and proportions of cases in the top 100 cities in China

Figure 1A shows the comparison between the proportions of travellers departing from Wuhan and proportions of cases in the selected top 100 cities in China. Between Jan 10, 2020 and Jan 24, 2020, 91.68% of all travellers departing from Wuhan travelled to the top 100 cities, with 69.34% of them to other 15 cities in Hubei province. The areas with a high proportion of travellers departing from Wuhan were correlated with a high proportion of COVID-19 cases. Compared to the proportion of travellers departing from Wuhan, most areas showed a lower proportion of cases. However, several well-developed areas, such as Zhejiang Province, Guangdong Province, Shanghai, and Beijing, showed a significantly higher proportion of cases compared to the proportion of travellers departing from Wuhan. Meanwhile, the population mobility departing from Wuhan before the Spring Festival in 2020 (yellow) and 2019 (white) is shown in Fig. 1B (provided by Baidu Migration). Our data may be an underestimation as not all cases are identified or are paucisymptomatic.[3]

Correlation between the proportion of travellers departing from Wuhan and four potential risk factors in the top 100 cities

We did not find a correlation between number of cases and the population density (P = 0.643), regional income (P = 0.617), or level of health care (P = 0.244). Meanwhile, there were no correlations between recovery rate and the population (P = 0.926), population density (P = 0.680), regional income (P = 0.073), or level of health care (P = 0.063). There was a strong positive correlation between the proportion of travellers departing from Wuhan and the number of cases (Spearman's r = 0.773, P = 0.000, Fig. 2A) or the proportion of cases (Spearman's r = 0.773, P = 0.000, Fig. 2B) in the top 100 cities. In addition, a strong positive correlation was also observed between the proportion of travellers departing from Wuhan and the number of the recovered cases (Spearman's r = 0.704, P = 0.000, Fig. 2C). Conversely, the correlation between the proportion of travellers departing from Wuhan and the recovery rate was negative in the top 100 cities (Spearman's r = -0.209, P = 0.037, Fig. 2D). The correlation between the proportion of travellers and the number of cases was positive, both in the subgroup of cities outside Hubei (r = 0.553, P = 0.000) and in the subgroup of cities in Hubei (r = 0.930, P = 0.000).

Conclusions

The main destination cities of travellers departing from Wuhan before the Spring Festival were other cities (n = 15) within Hubei province and the cities (n = 40) in the

neighboring provinces. We found a strong correlation between travellers departing from Wuhan before the Spring Festival and the extent of amplification of the outbreak of COVID-19 in China.

The timing of the outbreak before the Spring Festival, and the transportation hub located in Wuhan accelerated the spread of COVID-19. Our results indicated that 69.34% of travellers departing from Wuhan travelled to other cities in Hubei Province. These areas also reported the largest number of cases, with a proportion of 54.98%. Travellers departing from Wuhan before the Spring Festival were the main infection source for other cities in China.

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References

1.   Bogoch, II, Watts A, Thomas-Bachli A, Huber C, Kraemer MUG, Khan K. Potential for global spread of a novel coronavirus from China. *J Travel Med* 2020.
2.   Hu M. Visualizing the largest annual human migration during the Spring Festival travel season in China.   Environment and Planning A: Economy and Space; 2019: 1618-21.
3.   Zhao S, Musa SS, Lin Q, et al. Estimating the Unreported Number of Novel Coronavirus (2019-nCoV) Cases in China in the First Half of January 2020: A Data-Driven Modelling Analysis of the Early Outbreak. *J Clin Med* 2020; **9**(2).
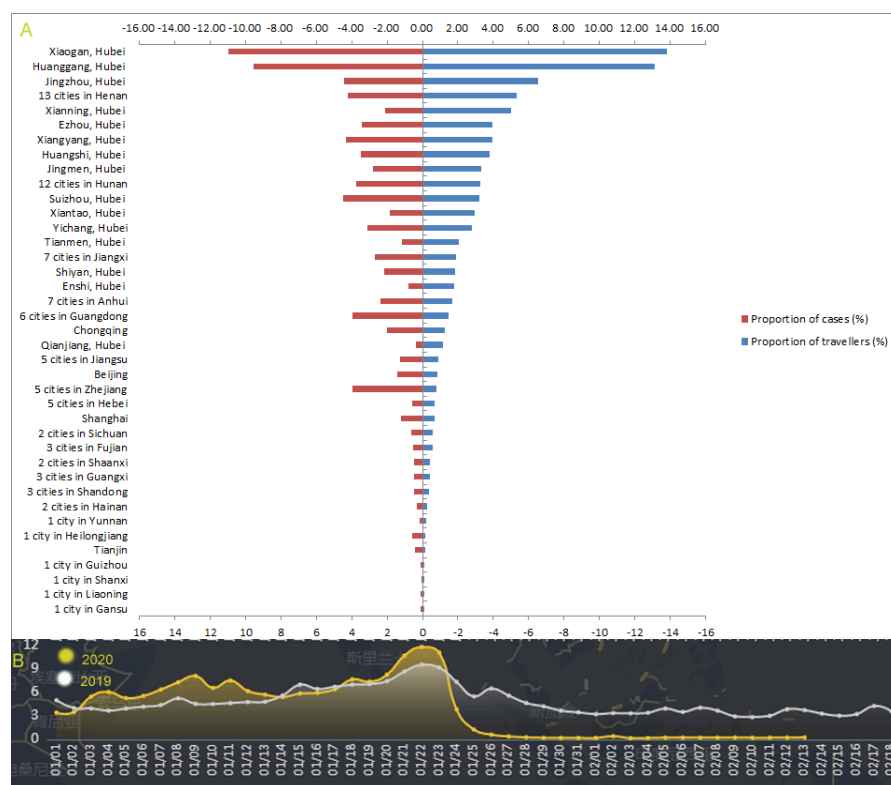
Figure legends

Figure 1 Comparison between proportions of travellers departing from Wuhan and proportions of cases in the top 100 cities in China.

The areas with a high proportion of travellers departing from Wuhan (blue) also companied with a high proportion of COVID-19 cases (red) (Fig. 1A). The travellers departing from Wuhan before the Spring Festival (Jan 25) were far more than those after the Spring Festival in 2020 (yellow) and 2019 (white) (Fig.1B).
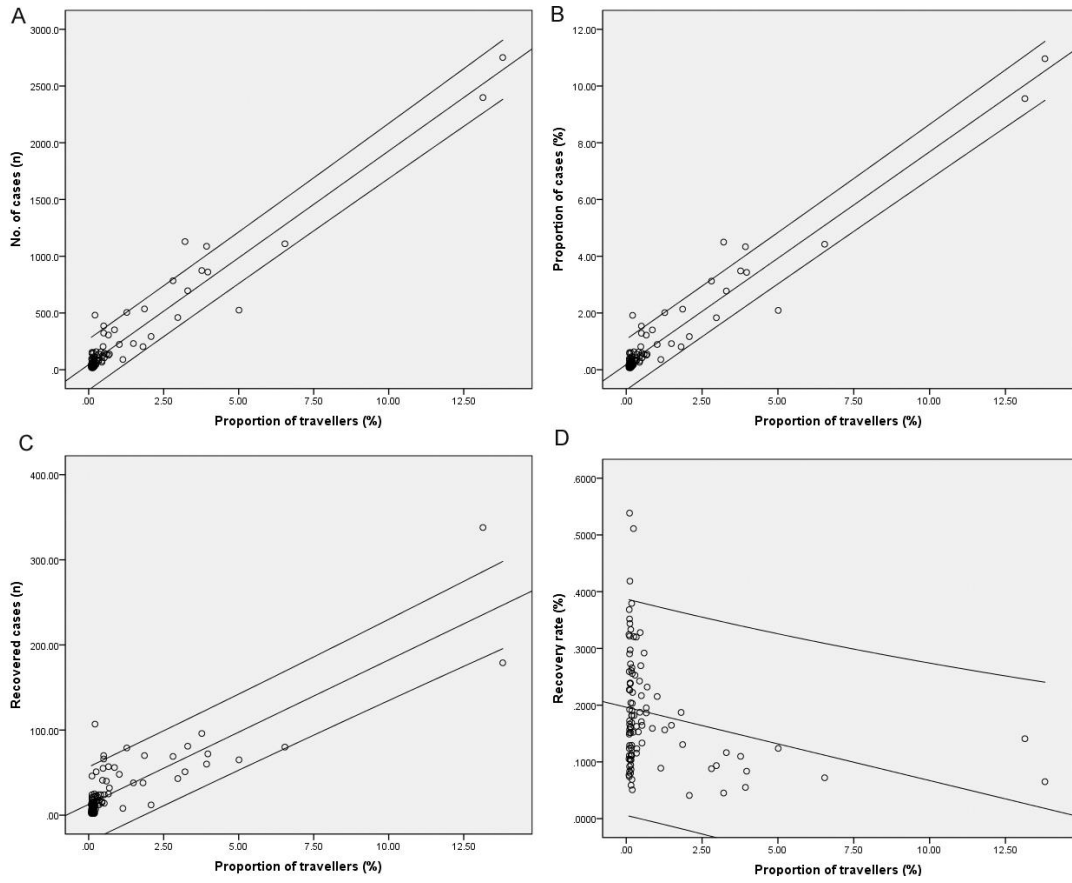
Figure 2 Scatter plots of the proportions of travellers departing from Wuhan and four

indexes of the extent of amplification of the outbreak of COVID-19 in the top 100 cities.