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The association between domestic train transportation and novel coronavirus (2019-nCoV) outbreak in China from 2019 to 2020: A data-driven correlational report

To the Editor

The atypical pneumonia case, caused by a novel coronavirus (2019-nCoV), was first identified and reported in Wuhan, China in December, 2019 [1]. As of January 21, 2020 (11:59 a.m., GMT + 8), there have been 215 cases of 2019-nCoV infections confirmed in mainland China. There were 198 domestic cases in Wuhan including 4 deaths, and 17 cases identified outside Wuhan including 8 in Shenzhen, 5 in Beijing, 2 in Shanghai and 2 in other places. The 2019-nCoV cases were also reported in Thailand, Japan and Republic of Korea, and all these cases were exported from Wuhan China, see WHO news release https://www.who.int/csr/don/en/from January 14–20, 2020. The first case outside Wuhan was confirmed in Shenzhen on January 3, 2020. Then, many major Chinese cities reported events of 'imported 2019-nCoV cases', thereafter, including Beijing and Shanghai. The outbreak is still on-going. And a recently published preprint by Imai *et al.* estimated that a total of 1723 (95%CI: 427–4471) cases of 2019-nCoV infections in Wuhan had onset of symptoms by January 12, 2020 [2].

Inspired by Ref. [3], which indicated the likelihood of travel related risks of 2019-nCoV spreading, we suspected the spread of infections could be associated with the domestic transportations in mainland China. Thus, we examine and explore the association between load of domestic passengers from Wuhan and the number of 2019-nCoV cases confirmed in different cities. The daily numbers of domestic passengers by means of transportation, i.e., car (road), train and flight, were obtained from the location-based services database of Tencent company from January 2016 to June 2019, see https://heat.qq.com/document.php (in Chinese). We calculated the daily average number of passengers from Wuhan to six selected major cities, including Beijing, Shanghai, Guangzhou, Shenzhen, Chengdu and Chongqing, from December 16 to January 15 of the next year. The location of the selected six major cities are shown in Fig. 1(A). Since the most recent transportation dataset, i.e., 2019–20, was not yet available, we used the data of the same period in the past three years, i.e., 2016–19, as the proxy in the analysis. The association can be constructed as in Eqn (1).

$$\mathrm{E}(\mathrm{case}) = \alpha \cdot \mathrm{period} + \beta \cdot \log(\mathrm{passenger}). \quad (1)$$

Here, the function $\mathbf{E}(\cdot)$ is the expectation. The 'period' is a dummy variable accounting for the difference in the passenger loads in the different periods of time. Thus, the α represents the effect of different period, which accounts for a period-varying interception term. The β is the regression coefficient to quantify the association. The 'passenger' is the daily number of domestic passengers, and it is in logarithm form with base of 10 in the regression model. Hence, the β can be interpreted as the number of imported 2019-nCoV cases associated with 10-fold increase in the daily number of passengers in average. We estimated and tested the βs for three means of transportation, i.e., car, train and flight. The p-value less than 0.05 is considered as statistical significance.

We found strong and significant association between travel by train and the number of 2019- nCoV cases, whereas the associations of the other two means of transportation failed to reach statistical significance, see Table 1. We estimated that 10-fold increase in the number of train passengers from Wuhan is likely to associated with 8.27, 95%CI: (0.35, 16.18), increase in the number of imported cases, see Fig. 1(B). As for sensitivity analysis, by slightly varying the time period of the transportation data, currently it is from December 16 to January 15 of the next year, this association still holds strongly and significantly. We remark that the estimates of β could be different as the 2019- nCoV outbreak situation updating, e.g., more reports on the imported cases in other cities, but the statistical significance of this relationship is unlikely to vary. Although this is a data-driven analysis, our findings suggest that disease control and prevention measures are preferred in the travelling procedure by trains. We remark that the analysis was conducted based on the epidemic data at early outbreak, and further investigation can be improved from more detailed datasets.

Ethics approval and consent to participate

The ethical approval or individual consent was not applicable.

Availability of data and materials

All data and materials used in this work were publicly available.

Consent for publication

Not applicable.

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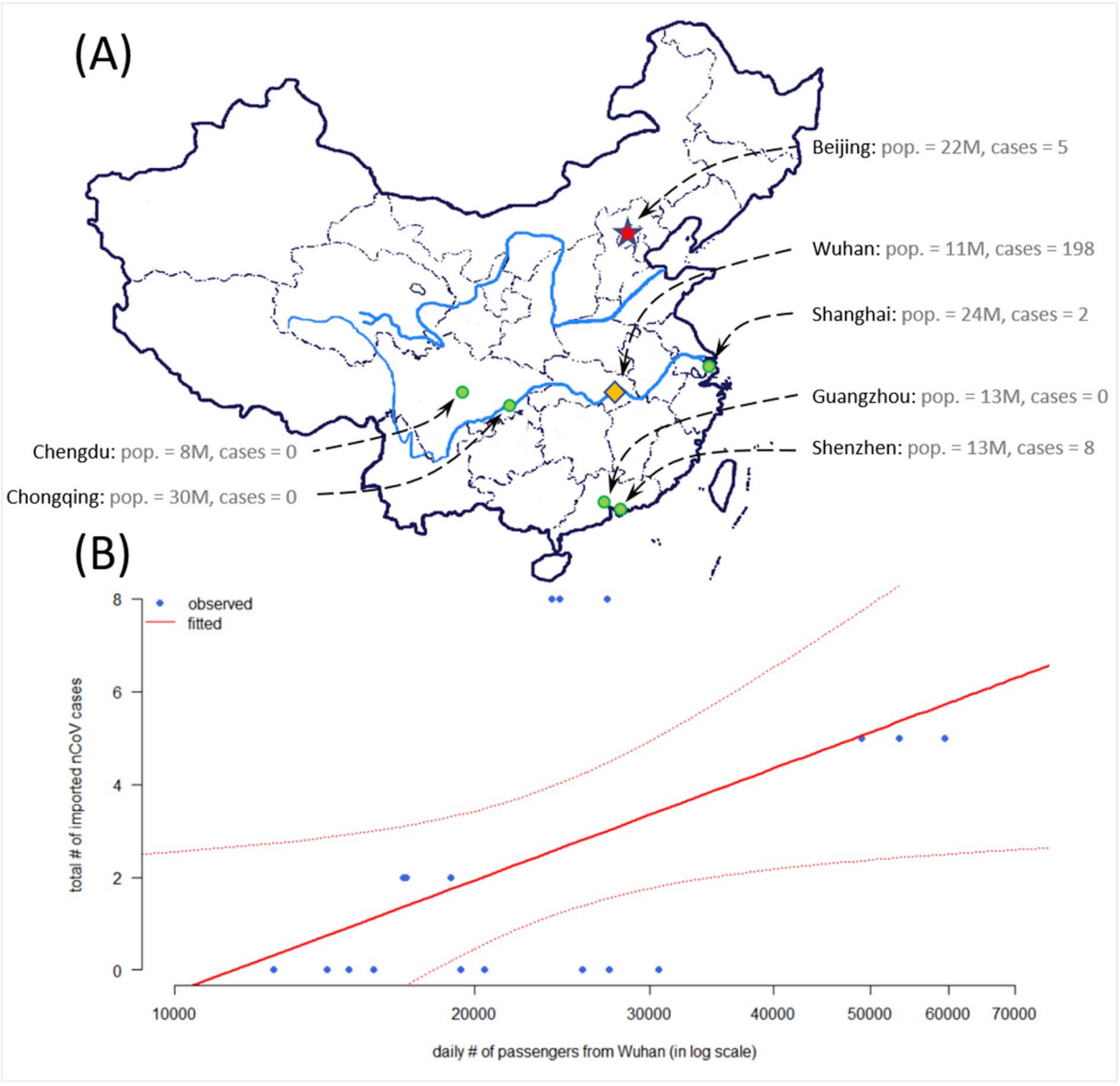

Fig. 1. The map of major cities with imported nCoV cases and the its regression fitting results against train transportation. Panel (A) shows the locations of the major cities with nCoV cases as of January 20, 2020. The red star represents Beijing, gold diamond represents Wuhan, which is believed to be the source of nCoV, and Shanghai, Guangzhou, Shenzhen, Chengdu and Chongqing are indicated by the green circles. The blue curves are the Yellow river (upper) and Yangtze river (lower). Panel (B) shows the daily number of passengers by train versus the total number of imported nCoV cases in each city. The observed data are in blue, the fitted regression model is the red line, and the 95%CI is shown as the red dashed line. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
The summary table of the estimated association between transportation and number of imported nCoV cases. The interpretation of the regression coefficient ('coeff.') is the number of imported nCoV cases associated with 10-fold increase in daily number of passengers in average.

Transportation	Proportion	coeff. (per 10-fold increase)	R-squared
train	68.72%	8.27 (0.35, 16.18), $p = 0.042$	0.26
car	11.85%	5.7 (−6.09, 17.5), $p = 0.317$	0.07
flight	19.42%	3.61 (−2.22, 9.44), $p = 0.206$	0.11

Note: the 'proportion' is percentage of the transportation of interest in all transportations.

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Authors' contributions

All authors conceived the study, carried out the analysis, discussed the results, drafted the first manuscript, critically read and revised the manuscript, and gave final approval for publication.

Declaration of competing interest

The authors declared no competing interests.

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