Role of media coverage in mitigating COVID-19 transmission: Evidence from China

Ning Liu, Zhuo Chen, Guoxian Bao

University of Nottingham Ningbo China, 199 Taikang East Road, Ningbo, 315100, Zhejiang, China.

First published 2020

University of Nottingham
UK | CHINA | MALAYSIA

Role of Media Coverage in COVID-19 Prevention and Control: Evidence from China

Ning Liu[1], *Zhuo Chen*[2,3*], *Guoxian Bao*[1]

1. School of Management, Lanzhou University, Lanzhou, China

2. College of Public Health, University of Georgia, Athens, Georgia, the United States

3. School of Economics, University of Nottingham Ningbo China, Ningbo, China

Abstract: This paper evaluates the impact of media coverage in mitigating the spread of COVID-19 in China during the early phase of the pandemic. We construct provincial-level data on media coverage and link with COVID-19 indicators and population mobility data, among other control variables. We estimate how media coverage mitigates the temporal and spatial spread of COVID-19. Seemingly unrelated regressions are used to examine the simultaneous impact of media coverage on the number of new cases and close contacts. The results show that the effect of media coverage on COVID-19 transmission in China has an inverse-U curvature and was mediated by within- and across-province population mobility. Based on our simulation results, media coverage in China is associated with a potential reduction of 394,000 COVID-19 cases and 1.4 million close contacts during January 19 and February 29. Our results also support the important role of contact tracing in mitigating the transmission of COVID-19.

Key words: COVID-19, China, media coverage, contact tracing, population mobility

[*] Correspond to: Dr. Zhuo Chen, Associate Professor, Department of Health Policy and Management, College of Public Health, The University of Georgia; Visiting Professor of Health Economics and Director (Academics), Centre for Health Economics, School of Economics, University of Nottingham Ningbo China. Mail Address: 100 Foster Rd, Wright Hall 305B, Athens, GA 30602, USA. Email: zchen1@uga.edu.

Role of Media Coverage in COVID-19 Prevention and Control: Evidence from China

1. Introduction

Effective implementation of government interventions and policies to prevent and control an ongoing pandemic relies on the support, compliance, and trust of the policies among the general public (Saksena, 2018). The course of a pandemic is determined by individual and collective actions of people (Gersovitz and Hammer, 2003), who internalize the information available to them. Thus, media coverage of an ongoing pandemics may play a crucial role in mitigating the spread of the pandemic. Information about the severity, mortality, and modes of transmission of the disease available to the public improves the compliance to government policies and directives (Gersovitz and Hammer, 2003).

COVID-19, a disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in China on December 30, 2019. It has since spread outside of China and was declared a worldwide pandemic on March 11, 2020. By July 9, 2020, China reported 85,399 cases of COVID-19 and 4,648 associated deaths (Guan *et al.*, 2020), while the global case count stood at 30,675,675 as of September 20, 2020 (World Health Organization, 2020). The cluster of unknown pneumonia cases was first reported in Wuhan, a megacity with a population of 11 million in Hubei province (Li *et al.*, 2020). Chinese central and local governments took extraordinary measures to implement a wide range of interventions and policies to control the spread of COVID-19, including contact tracing, identifying the causative pathogen, genomic characterization of the pathogen, developing testing kits, mandating the use of facemasks, and social distancing (Chen *et al.*, 2020; Zhu *et al.*, 2020). On January 20, China activated the highest level of public health emergency mobilization across all sectors in response to the COVID-19 epidemic (Figure 1). The City of Wuhan was shutdown to limit mobility starting on January 23. In late February 2020, the exponential growth of the number of confirmed cases in China was tamped down (Maier and Brockmann, 2020).

The prevention and control of COVID-19 in China is challenging. Wuhan is a crucial transportation hub in central China with connecting railway and flight networks. The Chinese Lunar New Year Holiday, January 24 to 30 in 2020, is one of the most celebrated national holidays in China, typically with more than 0.45 billion travelers in January and early February (Tian *et al.*, 2020). The intense population mobility associated with Wuhan and the holiday season, coupled with a completely new disease with many features unbeknownst to the scientists even many months later, has posed a challenge to the Chinese authorities with profound consequences. Given China had experienced a similar but smaller epidemic in 2003 for the spread of SARS, there is a debate about if, when, and how information availability and media coverage have mitigated the spread of the pandemic.

Media coverage has a crucial role in disseminating and advocating public policies and information when emergencies occur, and in securing the public's attention, support, and compliance (Degeling and Kerridge, 2013; Otten, 1992). The emergency of a new infectious disease might lead to confusion and panic if no proper information was available in time. For example, compliance with the home isolation policy had been an issue in Israel when the public was not well informed on home isolation policies and guidelines (Dickens *et al.*, 2020). Media coverage has been examined in political science, finance, and health (Boukes *et al.*, 2015; Cieslak and Schrimpf, 2019; Jarlenski and Barry, 2013; Kasper *et al.*, 2015). In public health, communication is key to disseminating information related to diseases and interventions, such as tobacco control (Smith *et al.*, 2008), mental illness (Wahl, 2003), obesity (Niederdeppe and Frosch, 2009), and infectious disease (Degeling and Kerridge, 2013; Saksena, 2018). Although there are debates that news report may be influenced by political considerations (Hayes *et al.*, 2007; Saksena, 2018), and how to 'frame' the events may have unintended consequences (Jarlenski and Barry, 2013; Kostadinova and Dimitrova, 2012), the news is still the primary, if imperfect, source of information for most people on public issues and debates (Jarlenski and Barry, 2013).

In this paper, we estimate the effects of media coverage on COVID-19 prevention and control in China. Following the Standard Inflammatory Response (SIR) model (or susceptible-infected- recovered model as referred to elsewhere) to investigate pandemic transmission outlined in Adda (2016), we model the within- and across-province spread of COVID-19 and the effects of provincial-specific media coverage using daily provincial-level data. We use the daily number of new cases and close contacts at the provincial-level to describe the temporal and spatial spread of COVID-19 and the daily accumulated number of official news reports on COVID-19 in every province to proxy provincial media coverage. We evaluate the impact of media coverage by simulating the counterfactual when media coverage was absent.

The remainder of this paper proceeds as follows. Section 2 describes the data. Section 3 outlines the econometric method used in the paper. Section 4 presents the study results. Section 5 describes the counterfactual simulations. Section 6 discusses, and Section 7 concludes.

2. Data

We compiled data on COVID-19, media coverage, population mobility, and control variables from various sources. The official data for COVID-19 since January 20, 2020, for Chinese provinces were available except Hubei, for which the data can be dated back to January 1, 2020, see, e.g., Tian *et al.*

(2020). Some provinces had lowered the level of emergency response, as shown in Figure 1, and gradually reopened in late February. Therefore, we chose the end of our study period as February 29.

2.1 COVID-19 Data

We extracted the number of daily new COVID-19 cases and the number of daily identified close contacts for the 31 provincial administrative units in mainland China from the websites of central and provincial health authorities. Most studies on COVID-19 from China use the daily number of confirmed cases as the major indicator of interest (Pan *et al.*, 2020; Qiu *et al.*, 2020; Tian *et al.*, 2020). We also examined the number of close contacts[1] because it is a crucial alternative measure of the spread of COVID-19, among which some confirmed COVID-19 infection later on. Successful prevention and control of the pandemic often involve intensive efforts in contact tracing, i.e., identifying close contacts of the confirmed case, and appropriate follow-up measures, including self-isolation or quarantining of the close contacts (Maier and Brockmann, 2020). Therefore, we use both indicators to examine the temporal and spatial spread of COVID-19 (see the temporal changes in Figure 2).

2.2 Media Coverage

We collected all the official news releases and reports about COVID-19 for each province to measure media coverage. We used the cumulative daily number of news reports and releases (#news) to measure the intensity of media coverage. The news reports were extracted by using Python from DXY Inc, a leading Chinese digital service provider and news synthesizing platform in the healthcare sector. DXY built an information portal for COVID-19 in early January, which had 41.6 billion visits by July 14, 2020.[2]

The first news release appeared on December 31, 2019, reporting 27 cases of pneumonia of unknown etiology in Wuhan. During our study period, there were a total of 7,321 official news releases and reports about COVID-19. We included both local news and reports released by the 31 provinces and the reports and news released at the national-level but relevant to a specific province. We constructed a final set of 1,849 news for 31 provinces (see Appendix A). Instead of content analysis, we calculated the cumulative number of news releases or reports for each province each day and then calculated the cumulative daily number of news to measure the extent of media coverage, as we have explained earlier. A detailed description of DXY data and the collection and measurement of the news releases and reports is in

[1] Most of the provinces in China had tracked the close contacts for every patient though we were not able to find such information for Beijing and Shanghai. We use the number of individuals under observation in Shanghai as a proxy, and calculated the number of close contacts of Beijing by subtracting from the national total the sum of close contacts of other provinces.

[2] The data can be accessed at https://ncov.dxy.cn/ncovh5/view/pneumonia.

Appendix A.

We chose to use *official* news reports from major news outlets and national and provincial health authorities' websites. News reports on the pandemic abound but authoritative information could be limited in the early stage of the pandemic (Degeling and Kerridge, 2013; Saksena, 2018). Official news releases and reports presented authoritative information with impact and accountability, led to concerted public responses, and helped to set public policy agendas (Jarlenski and Barry, 2013). Other news sources had often used and adapted those reports.

We used the daily cumulated number of news releases and reports as a key measure of media coverage. The information on COVID-19, particularly the scientific findings and prevention and control policies, had been continuously developing and adapting, posing difficulties for content analysis. Thus, instead of the content analysis commonly used in communication studies, we chose to use the daily cumulated number of official news reports as a measure of media coverage.

2.3 Population Mobility

The population mobility indicators included the index of population inflow across provinces and the index of within-province population movement into the capital city of the provinces from the Baidu Inc.[3] Baidu launched its product "Baidu Mobility (*Baidu Qianxi* in Chinese)" in 2014, which illustrates daily population inflow for every province using mapping tools and information technologies including Location-based Services. The plots of population inflow and movement in every province are shown in Appendix B. The Baidu mobility data and similar data from Tencent have been used in COVID-19 research in China elsewhere (Qiu *et al.*, 2020; Tian *et al.*, 2020).

2.4 Control variables

Our control variables included provincial-level weather data, area, and inter-province distance indicated by the distance between capital cities. The data on area and distance were collected and calculated from the 2018 China Statistical Yearbook and the China Land & Resources Almanac.

Weather and temperature may affect the life span and transmission of SARS-COV-2 (Lin *et al.*, 2006), through both the direct effect on the virus and the indirect effect through behavioral changes related to social gatherings (Adda, 2016). We used daily average temperature, wind, and precipitation of the capital city for every province to indicate the daily weather as in Qiu *et al.* (2020). The weather data was

[3] The data can be reached from the website http://qianxi.baidu.com.

collected from the National Meteorological Center of China Meteorological Administration (http://www.nmc.cn/).

Earlier studies used variables, including the provincial per-capita GDP, as socioeconomics mediating factors (Qiu *et al.*, 2020; Tian *et al.*, 2020). Our provincial fixed-effects would capture the provincial-level socioeconomic conditions.

Appendix C provides the description and summary statistics of key variables.

3. Econometric specification

To explore the impacts of economic activity on the spread of infectious disease, Adda (2016) developed a within- and across-province model (hereinafter Adda model). Our model extended the SIR model and described a more comprehensive model, in which the spread of infectious disease depends on the local number of cases and population inflow.

We estimated the effects of media coverage with lags of 3-, 5-, and 7-days to model the impact of different incubation periods because the reported incubation period of SARS-CoV-2 is about 5.2 days (Guan *et al.*, 2020; Li *et al.*, 2020). We also estimated the potential effects of media coverage on COVID-19 prevention and control through reduced within- and across-province population mobility.

3.1 The within-province model

We began our estimation by the traditional within-province model as presented in the Seemingly Unrelated Regression (SUR) system, equation (1) and (2), to explore the spread of COVID-19.

$$I_{it} = \alpha_{within} I_{i(t-l)} S_{i(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (1)$$

$$C_{it} = \alpha_{within} I_{i(t-l)} S_{i(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (2)$$

I_{it} and C_{it} are the logarithmic transformation of daily new patients and close contacts in the province i on day t. $S_{i(t-l)}$ is susceptible population, and l is incubation time. The lagged $I_{i(t-l)} S_{i(t-l)}$ is also in the logarithmic form. X_{it} indicates control variables including provincial and date fixed effects. To test the potential variation in the incubation period, we set l to be 3, 5 and 7 days. We also use equation (3) and (4) to explore the daily transformation between daily new patients and close contacts.

$$I_{it} = \alpha_{within} I_{i(t-l)} S_{i(t-l)} + \beta C_{it} + X_{it}\varphi + \varepsilon_{it} \quad (3)$$

$$C_{it} = \alpha_{within} I_{i(t-l)} S_{i(t-l)} + \beta I_{it} + X_{it}\varphi + \varepsilon_{it} \quad (4)$$

The calculation of the susceptible population is a challenge. There was no vaccine for COVID-19 during the study period, thus anyone could be infected – although 87% of the patients aged between 30-79 (Wu and McGoogan, 2020). We chose to use the whole provincial population to proxy the susceptible population but recognize its limitations. Studies suggested a portion of the populations may be less likely to have COVID-19 because of prior infections of the common strains of coronavirus. However, if the proportion does not vary significantly across the provinces, which seems to be the case, our use of the provincial population only changes the scale of the coefficient.

3.2 The basic across-province model

Equation (3) and (4) indicate that the spread of virus and disease in each province will be affected by the within- and across-province infection.

$$I_{it} = \alpha_{within} I_{it-l} S_{i(t-l)} + \alpha_{across} \sum_{j \neq i} I_{jt-l} S_{i(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (5)$$

$$C_{it} = \alpha_{within} I_{it-l} S_{i(t-l)} + \alpha_{across} \sum_{j \neq i} I_{jt-l} S_{i(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (6)$$

I_{it}, C_{it} and $I_{it-l} S_{it-l}$ are also logarithmically transformed, and j is province other than i. X_{it} indicates control variables including provincial and daily fixed effects and the full control of land areas in the province, inter-province distances, and weather conditions. To capture the differences in closeness across provinces, we weight $I_{jt-l} S_{i(t-l)}$ by the inverse of the distance between the two provinces. The same transformation of new patients and close contacts is estimated by equation (7) and (8). Identified new COVID-19 cases and close contacts would be quarantined or under medical observation in the province where their condition or status was ascertained, so we chose not to include the across-province item for I_{it} and C_{it} in the right side of equation (7) and (8), and the same treatment is used the following estimations.

$$I_{it} = \alpha_{within} I_{it-l} S_{i(t-l)} + \alpha_{across} \sum_{j \neq i} I_{jt-l} S_{i(t-l)} + \beta C_{it} + \varphi X_{it} + \varepsilon_{it} \quad (7)$$

$$C_{it} = \alpha_{within} I_{it-l} S_{i(t-l)} + \alpha_{across} \sum_{j \neq i} I_{jt-l} S_{i(t-l)} + \beta I_{it} + \varphi X_{it} + \varepsilon_{it} \quad (8)$$

3.3 The full across-province model

The equation (9)-(12) follows equation (5)-(8) where the spread of the virus and disease may be determined by both within- and across-province factors. $B^{r}_{i(t-l)}$ and $\hat{B}^{r}_{j(t-l)}$ are lagged province-specific variable vectors (with dimensions being R and $\hat{R}$) that may influence the spread of disease within- and across-province.

$$I_{it} = I_{it-l}S_{i(t-l)}\sum_{r=1}^{R}\alpha^{r}_{within}B^{r}_{i(t-l)} + \sum_{j\neq i}\sum_{r=1}^{\hat{R}}\alpha^{r}_{across}I_{j(t-l)}S_{j(t-l)}\hat{B}^{r}_{j(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (9)$$

$$C_{it} = I_{it-l}S_{i(t-l)}\sum_{r=1}^{R}\alpha^{r}_{within}B^{r}_{i(t-l)} + \sum_{j\neq i}\sum_{r=1}^{\hat{R}}\alpha^{r}_{across}I_{j(t-l)}S_{j(t-l)}\hat{B}^{r}_{j(t-l)} + \varphi X_{it} + \varepsilon_{it} \quad (10)$$

$$I_{it} = I_{it-l}S_{i(t-l)}\sum_{r=1}^{R}\alpha^{r}_{within}B^{r}_{i(t-l)} + \sum_{j\neq i}\sum_{r=1}^{\hat{R}}\alpha^{r}_{across}I_{j(t-l)}S_{j(t-l)}\hat{B}^{r}_{j(t-l)} + \beta C_{jt} + \varphi X_{it} + \varepsilon_{it} \quad (11)$$

$$C_{it} = I_{it-l}S_{i(t-l)}\sum_{r=1}^{R}\alpha^{r}_{within}B^{r}_{i(t-l)} + \sum_{j\neq i}\sum_{r=1}^{\hat{R}}\alpha^{r}_{across}I_{j(t-l)}S_{j(t-l)}\hat{B}^{r}_{j(t-l)} + \beta I_{jt} + \varphi X_{it} + \varepsilon_{it} \quad (12)$$

3.4 Separate Regressions: Before and After February 5

We run separate regressions for the full sample (T) and two subsamples, i.e., the sample before February 5 (T_1) and the sample after February 5 (T_2), as the national number of new confirmed cases peaked on February 5. We intended to examine the difference in the patterns before and after the peak.

3.5 Robustness Check: Excluding Hubei province

Data for Hubei province were amended on April 16, with 325 cases added due to previous omissions or misreporting. However, there was no information as to on which dates the added cases occurred. In addition, a large portion of the cases occurred in Hubei. Therefore, as a robustness check, we run additional estimations using the sample, excluding data from Hubei.

4. Results

4.1 Baseline models

Table 1 presents the results for estimating equation (1)-(4). When the lag is set at 3 and the full time period (T) is used, a 100% change in the number of new cases is associated with 24% increase in the number of news cases three days later,[4] and a 100% increase in the number of close contacts is associated with an increase of 27% in the number of close contacts 3 days later. After adding the current period of close contacts and new cases as explanatory variables in the SUR estimation, a 100% increase in the

[4] We do not standardize the susceptible population to be one, and the unit may be not individual patients as showed in other studies. The following analysis adopts the same strategy.

number of close contacts is associated with an increase of 26% in the number of new cases, while a 100% increase in the confirmed case leads to an increase of 109% in the number of close contacts. Separate regressions for the samples before and after February 5 suggest that the effects are stronger in t_1 and reduced in t_2. The impact also decreased as the lag increases from 3 days to 7 days, except for the association between daily new cases and close contacts, which has strengthened across the models with the lag of 3-, 5- to 7 days.

Results of equation (5)-(8) are in Table 2. After adding the inter-province correlation (α_{across}), results for the within effect and the association between the number of close contacts and new cases only have trivial changes. Across effect (α_{across}) is only statistically significant for the whole time period (T) and after February 5 (T_2). The across-effect of new cases is positive in the estimation for the models with a 5-day lag, consistent with the conjecture that the incidence in one province generates additional incidence in other provinces (Adda, 2016). However, results of across effect for the number of close contacts are difficult to interpret for the models with 3- and 5-days lag.

4.2 The impact of media coverage

We estimate equation (9) and (12) with a set of variables on media coverage. We include a quadratic term of the number of news reports as media coverage may have a nonlinear impact on the pandemic's spread. Media coverage might increase as the number of cases grew, but at the later stage of the epidemic, the cumulative impact of new coverage will exhibit and limit the spread of the disease through reduced mobility and adherence to social distancing and other prevention and control measures.

The estimation results are presented in Table 3. Media coverage has a limited impact on the spread of this epidemic in the early stage, but the impact grew stronger after February 5 (T_2). Media coverage in other provinces have statistically significant but small effects on the number of close contacts for the models with 3 and 5-day lags. The magnitude of the impact of media coverage decreased as the lag increased from 3, 5, to 7-days. The introduction of media coverage has only trivial changes on the association between the number of new cases and the number of close contacts relative to the baseline models.

4.3 The effects of population mobility

Tian *et al.* (2020) confirmed that the number of cases in a province has a strong and positive correlation with the population outflow from Wuhan in the early stage. To test whether the effects of control policies can be mediated by population mobility, we estimate equations (9)-(12) with data of within- and across-province population inflow and movement. The within province population movement may have a limited impact on disease spread in other provinces, and we only included the population inflow into a province. Because population inflow and outflow are often correlated, we used the net inflow to proxy the population movement.

The results for equations (9)-(12) are presented in Table 4. Consistent with the conventional wisdom, the increase of population movement is associated with a higher number of confirmed cases. An increase of one unit of the population mobility index within a province increases the number of new cases by 14%, and a one-unit change in the inflow mobility index within a province and across provinces will increase the number of new cases by 17% and 1%, respectively. Similarly, a one-unit increase in population mobility index within a province led to a 23% increase in the number of close contacts. The changes in the number of close contacts are 5% and −3% for a 100% increase in population inflow in one province and other provinces.

4.4 The mediate effect of media coverage through population mobility

Media coverage may reduce the intensity of population mobility and increase adherence to the mandates of facemask wearing and social distancing. To test this hypothesis that population mobility is a mediating factor for media coverage, we follow the strategy of Baron and Kenny (1986) to regress the within- and across-province population mobility on media coverage. The results are presented in Appendix D. Media coverage will reduce the intensity of within- and across-province population mobility and the effects are stronger in the early stage. Within-province population mobility is not only controlled by the within-province media coverage but also affected by media coverage of other provinces that may increase population inflow.

We estimate the equations (9) and (12) with the inclusion of media coverage and population mobility. The results are reported in Table 5, which shows the increasing effects of media coverage and the decreasing effects of population mobility. Several coefficients of population mobility have changed from positive to negative, which may reflect that people may move out of population centers that had experienced high incidence rates of COVID-19.

4.5 Robustness Check with Hubei excluded

As a robustness check, we estimated the models with the sample excluding the province of Hubei. The results of the set of regressions on the sample excluding Hubei are in Appendix D. For the baseline model, while the main results remain the same, it appears that the epidemic transmission is slightly weaker in the provinces other than Hubei except for spatial expansion. That may be because of delayed and less intensive media coverage in provinces other than Hubei. For the model on media coverage, the sample with Hubei shows stronger impacts of media coverage, potentially because the other provinces saw the situation in Wuhan and were more informed and organized than Wuhan at the initial stage of the epidemic.

5. Does media coverage work?

The impact of media coverage on COVID-19 transmission in China could be assessed by simulating the possible outcomes if media coverage actions were absent. Qiu *et al.* (2020) simulated the counterfactual impact of control policies and concluded the potential cases averted was about 1.4 million by February 29, 2020. We use the same counterfactual strategy to simulate what would be if media coverage had been absent.

We follow the method used by Tian *et al.* (2020) to replace the within- and across-province population mobility index since the launch of the Level I response with the value of the index on the same day and month in 2019. The across population inflow and the within-province population movement have a similar trend of variation in 2019 and 2020 before the activation of the Level I Response but varied much afterward (Appendix Figure B2 and B3). Our counterfactual simulations are based on the discussions in the methodology section, and we limit the dates to from January 19 to February 29. We simulate the counterfactual outcomes where there was no media coverage with the population mobility indices kept as those in 2019 and other control variables unchanged.

The results of the daily patients in Figure 3 indicate that the counterfactual total cumulative cases during January 19 to February 29 would be 394,032 (95% CI, 354,646 − 434,147), 237,836.3 (95% CI, 221,870 − 253,803), and 181,953 (95% CI, 169,095 − 194,811) for the 3, 5, and 7-days lag models. It is about 4.9, 3.0, and 2.3 times of the true number of cases (80,084). Figure 4 reports the results of the counterfactual cumulative number of close contacts as 817,943 (95% CI, 796,157 − 839,730) for the 3-days lag model, 1,082,440 (95% CI, 1,045,493 − 1,119,388) for the 5-days lag model, and 1,434,441 (95% CI, 1,376,103 − 1,492,778) for the 7-day lag model.

6. Discussions

This paper uses an augmented SIR model to estimate the COVID-19 transmission in China from January 19 – February 29 and assess the impact of media coverage on the spread of the epidemic after controlling provincial confounding factors and population mobility. Key findings include the following. First, a higher transmission rate during the early stage (before February 5) versus the late stage (from February 5 to February 29) is observed. The early-stage of the pandemic saw a stronger effect of the number of close contacts on the number of new cases, potentially the result of more widespread testing. The number of close contacts associated with additional new cases was higher in the early stage than after February 5, reflecting more stringent prevention and control policies that may have reduced the number of close contacts. Second, the effect of media coverage on the spread of COVID-19 has an inverse-U shape and has a net effect in reducing the number of new cases and close contacts. Third, the increase of within- and across-province population mobility is associated with higher risks of being infected. However, the population mobility may be reduced by increased media coverage of the COVID-19 pandemic. Our counterfactual simulation indicates that media coverage has substantially mitigated the temporal and spatial spread of COVID-19.

Our use of the number of close contacts is new to the literature, and the results have important policy implications. An increase of 100% in the number of close contacts were associated with an increase of 26% in the number of COVID-19 cases during the study period. However, the earlier time period (January 19 - February 5) saw a much stronger correlation, with the associated increase in the number of cases at 44%. In contrast, the percentage was lowered to 12% after February 5, potentially due to increased accessibility of COVID-19 tests and reduced social activities. Similarly, the percentage increase in close contacts due to the number of new cases was 109% and 137% before February 5 and 47% afterward. Those results indicate the importance of contact tracing as new cases can be identified and quarantined preeminently. The pattern may also provide evidence of the policies adopted in China during February 2020 as the two variables (the number of new cases and the number of close contacts) have decoupled. Those policies may include increased testing, social distancing, and the wearing of facemasks. However, we cannot assess the effects of the different components of the prevention and control policies.

This paper has additional implications for the understanding of COVID-19 prevention and control. First, this paper is one of the few works to evaluate the impact of media coverage on COVID-19 transmission. Although prior studies, e.g., Fang *et al.* (2020), Qiu *et al.* (2020), and Tian *et al.* (2020), have estimated the impacts of COVID-19 prevention and control policies in China, the effect of media coverage remains unknown. Second, we provide alternative indicators for the spread of COVID-19. Most available studies used the daily or accumulated number of confirmed cases to measure the spread of COVID-19 (Jia *et al.*, 2020; Qiu *et al.*, 2020; Tian *et al.*, 2020), which describes the variation of disease transmission but cannot portray the spatial dynamics across provinces. Third, we offer additional evidence on the incubation period of COVID-19. Previous studies conclude that the incubation of COVID-19 is about 5.2 days or longer (Guan *et al.*, 2020; Li *et al.*, 2020). We set 3-, 5-, and 7-days incubation to run the estimation, and find that the transmission would decrease along these incubations. Our results are confirmed by Zhang *et al.* (2020), which identified a threshold from a slow- to a fast-growing phase for COVID-19 at 5.5 (95% CI, 4.6–6.4) days after reporting of the symptoms. Fourth, we shed light on the relation between media coverage, population mobility, and COVID-19 transmission. Mobility may be correlated with higher risks of infectious disease transmission (Balcan *et al.*, 2009; Brockmann and Helbing, 2013). Several earlier studies have investigated how the population mobility, which was amplified by the Lunar New Year Holiday, has affected the scale and range of the COVID-19 outbreak (Fang *et al.*, 2020; Jia *et al.*, 2020; Qiu *et al.*, 2020; Tian *et al.*, 2020). We included a novel pathway of the impact of the media coverage, i.e., through reduced human mobility. We documented a mediating effect of population mobility where the media coverage reduces within- and across-province population mobility.

This study has two important limitations. First, our measure of media coverage does not measure the extent of the news releases and reports reaching the local population and whether the population in a province would respond to news reports on cases in neighboring provinces. However, as interprovince mobility has dramatically reduced during our study period, the cross-province of media coverage may be limited. Second, we were not able to calculate province-specific impacts of cross-province mobility. We did not differentiate neighboring provinces and non-contiguous provinces – although such differences may be diminished with the wide use of highspeed railway networks and extensive air travels in China.

7. Conclusions

This paper estimates the transmission of COVID-19 during the early phase of the pandemic in China and the effects of media coverage on the control of the COVID-19 pandemic. Our analysis highlights the importance of contact tracing in containing the COVID-19 pandemic. We have considered within- and across-province transmission and explore whether media coverage was effective, how they work, and the counterfactual impact of absent media coverage. We use the cumulative daily number of official news releases and reports about COVID-19 to measure the media coverage and examine how it is related to the numbers of confirmed cases and close contacts. Our counterfactual simulations suggest that media coverage of COVID-19 in China may have averted 394,000 additional new infections from January 19 to February 29.

Future research may explore the causal pathways between media coverage and reduced COVID-19, including reduced population mobility, increased adherence to COVID-19 prevention and control measures, including social distancing and wearing of facemasks.

Authors' Contributions

Guoxian Bao: Conceptualization; Funding acquisition
Ning Liu: Conceptualization; Data curation; Formal analysis; Writing - original draft
Zhuo Chen: Conceptualization; Formal analysis; Methodology; Supervision; Writing - review & editing

Biographies

Dr. Ning Liu is an Assistant Professor of Management in the School of Management at Lanzhou University, China. His research interest focuses on economic and policy analysis of healthcare including health insurance, health care reform and hospital management. He has a PhD in management and an MD degree, as well as work experience in healthcare and finance sectors.

Dr. Zhuo (Adam) Chen is Associate Professor of Health Policy and Management, College of Public Health, University of Georgia, Athens, Georgia, USA; and Visiting Professor in Health Economics and Director (Academics), Centre for Health Economics, School of Economics, University of Nottingham Ningbo China. He earned his Ph.D. in Economics and M.S. in Statistics from the Iowa State University. His works have been published in *Health Economics*, *Journal of Health Economics*, *Genetics in Medicine*, *Social Science & Medicine*, and *Mortality and Morbidity Weekly Report*. He is a recipient of the US CDC Excellence in Social and Behavioral Science Research Award in 2013. Dr. Chen's ORCID profile is available at https://orcid.org/0000-0002-5351-3489.

Professor Guoxian Bao is the Honorary Dean and Professor of Management in the School of Management at Lanzhou University, China. His research focuses on theory of public administration and government performance.

Reference

Adda, J. (2016). Economic Activity and the Spread of Viral Diseases: Evidence from High Frequency Data. *The Quarterly Journal of Economics,* 131, 891-941.

Balcan, D., Colizza, V., Gonçalves, B., Hu, H., Ramasco, J.J., and Vespignani, A. (2009). Multiscale mobility networks and the spatial spreading of infectious diseases. *Proceedings of the National Academy of Sciences,* 106, 21484-21489.

Baron, R.M., and Kenny, D.A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology,* 51, 1173-1182.

Boukes, M., Boomgaarden, H.G., Moorman, M., and Vreese, C.H.d. (2015). Political News with a Personal Touch. *Journalism & Mass Communication Quarterly,* 92, 121-141.

Brockmann, D., and Helbing, D. (2013). The Hidden Geometry of Complex, Network-Driven Contagion Phenomena. *Science,* 342, 1337-1342.

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., et al. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet,* 395, 507-513.

Cieslak, A., and Schrimpf, A. (2019). Non-monetary news in central bank communication. *Journal of International Economics,* 118, 293-315.

Degeling, C., and Kerridge, I. (2013). Hendra in the news: Public policy meets public morality in times of zoonotic uncertainty. *Social Science and Medicine,* 82, 156-163.

Dickens, B.L., Koo, J.R., Wilder-Smith, A., and Cook, A.R. (2020). Institutional, not home-based, isolation could contain the COVID-19 outbreak. *The Lancet,* 395, 1541-1542.

Fang, H., Wang, L., and Yang, Y. (2020). Human Mobility Restrictions and the Spread of the Novel Coronavirus (2019-nCoV) in China. *NBER Working Paper,* No.26906.

Gersovitz, M., and Hammer, J.S. (2003). Infectious Diseases, Public Policy, and the Marriage of Economics and Epidemiology. *The World Bank Research Observer,* 18, 129-157.

Guan, W.-j., Ni, Z.-y., Hu, Y., Liang, W.-h., Ou, C.-q., He, J.-x., et al. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China. *New England Journal of Medicine*, 1708-1720.

Hayes, M., Ross, I.E., Gasher, M., Gutstein, D., Dunn, J.R., and Hackett, R.A. (2007). Telling stories: News media, health literacy and public policy in Canada. *Social Science and Medicine,* 64, 1842-1852.

Jarlenski, M., and Barry, C.L. (2013). News Media Coverage of Trans Fat: Health Risks and Policy Responses. *Health Communication,* 28, 209-216.

Jia, J.S., Lu, X., Yuan, Y., Xu, G., Jia, J., and Christakis, N.A. (2020). Population flow drives spatio-temporal distribution of COVID-19 in China. *Nature,* 582, 389–394.

Kasper, M., Kogler, C., and Kirchler, E. (2015). Tax policy and the news: An empirical analysis of taxpayers' perceptions of tax-related media coverage and its impact on tax compliance. *Journal of Behavioral and Experimental Economics,* 54, 58-63.

Kostadinova, P., and Dimitrova, D.V. (2012). Communicating policy change: Media framing of economic news in post-communist Bulgaria. *European Journal of Communication,* 27, 171-186.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., et al. (2020). Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. *New England Journal of Medicine,* 382, 1199-1207.

Lin, K., Yee-Tak Fong, D., Zhu, B., and Karlberg, J. (2006). Environmental factors on the SARS epidemic: air temperature, passage of time and multiplicative effect of hospital infection. *Epidemiology and Infection,* 134, 223-230.

Maier, B., and Brockmann, D. (2020). Effective containment explains subexponential growth in recent confirmed COVID-19 cases in China. *Science*, eabb4557.

Niederdeppe, J., and Frosch, D.L. (2009). News Coverage and Sales of Products with Trans Fat: Effects Before and After Changes in Federal Labeling Policy. *American Journal of Preventive Medicine,* 36, 395-401.

Otten, L.A. (1992). The Influence of the Mass Media on Health Policy. *Health Affairs,* 11, 111-118.

Pan, A., Liu, L., Wang, C., Guo, H., Hao, X., Wang, Q., et al. (2020). Association of Public Health Interventions With the Epidemiology of the COVID-19 Outbreak in Wuhan, China. *JAMA,* 323, 1915-1923.

Qiu, Y., Chen, X., and Shi, W. (2020). Impacts of Social and Economic Factors on the Transmission of Coronavirus Disease 2019 (COVID-19) in China. *Journal of Population Economics,* Forthcoming.

Saksena, M. (2018). Framing Infectious Diseases: Effective Policy Implementation and United States Public Opinion. In A. Kachuyevski, & L.M. Samuel (Eds.), *Doing Qualitative Research in Politics: Integrating Theory Building and Policy Relevance* pp. 111-131). Cham: Springer International Publishing.

Smith, K.C., Siebel, C., Pham, L., Cho, J., Singer, R.F., Chaloupka, F.J., et al. (2008). News on tobacco and public attitudes toward smokefree air policies in the United States. *Health Policy,* 86, 42-52.

Tian, H., Liu, Y., Li, Y., Wu, C.-H., Chen, B., Kraemer, M.U.G., et al. (2020). An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China. *Science*, eabb6105.

Wahl, O.F. (2003). News Media Portrayal of Mental Illness: Implications for Public Policy. *American Behavioral Scientist,* 46, 1594-1600.

World Health Organization. (2020). WHO Coronavirus Disease (COVID-19) Dashboard.

Wu, Z., and McGoogan, J.M. (2020). Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA,* 323, 1239-1242.

Zhang, L., Tao, Y., Wang, J., Ong, J.J., Tang, W., Zou, M., et al. (2020). Early characteristics of the COVID-19 outbreak predict the subsequent epidemic scope. *International Journal of Infectious Diseases,* 97, 219-224.

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., et al. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *New England Journal of Medicine,* 382, 727-733.

Table 1. Daily spread of COVID−19 within province

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
$a_{within,}$	0.24^{***}	0.27^{***}	0.30^{***}	0.33^{***}	0.10^{***}	0.17^{***}	0.17^{***}	0.01	0.15^{***}	-0.08^{***}	0.08^{***}	0.12^{***}
	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)
Close contacts							0.26^{***}		0.44^{***}		0.12^{***}	
							(0.01)		(0.01)		(0.02)	
New cases								1.09^{***}		1.37^{***}		0.47^{***}
								(0.05)		(0.04)		(0.07)
N	1767	1767	961	961	806	806	1767	1767	961	961	806	806
Panel B: 5 days lag												
a_{within}	0.20^{***}	0.26^{***}	0.25^{***}	0.28^{***}	0.06^{***}	0.23^{***}	0.13^{***}	0.05^{*}	0.11^{***}	-0.06^{**}	0.03^{**}	0.20^{***}
	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
Close contacts							0.27^{***}		0.47^{***}		0.13^{***}	
							(0.01)		(0.02)		(0.02)	
New cases								1.08^{***}		1.37^{***}		0.49^{***}
								(0.04)		(0.04)		(0.07)
N	1705	1705	899	899	806	806	1705	1705	899	899	806	806
Panel C: 7 days lag												
a_{within}	0.16^{***}	0.18^{***}	0.24^{***}	0.21^{***}	0.03^{*}	0.12^{***}	0.11^{***}	−0.01	0.15^{***}	-0.14^{***}	0.01	0.10^{***}
	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.04)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.04)
Close contacts							0.28^{***}		0.47^{***}		0.15^{***}	
							(0.01)		(0.01)		(0.02)	
New cases								1.14^{***}		1.43^{***}		0.57^{***}
								(0.04)		(0.05)		(0.07)
N	1643	1643	837	837	806	806	1643	1643	837	837	806	806
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	×	×	×	×	×	×	×	×	×	×	×	×

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=new cases, *C*=Close contacts.

Table 2. Daily spread of COVID−19 across provinces

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
a_{within}	0.23***	0.23***	0.29***	0.34***	0.10***	0.13***	0.17***	−0.03	0.14***	−0.06	0.08***	0.09**
	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.03)
a_{acros}	−0.01	−0.04**	−0.01	0.01	−0.00	−0.04**	0.00	−0.03*	−0.01	0.02	0.00	−0.04**
	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)
							0.26***		0.44***		0.12***	
Close contacts							(0.01)		(0.01)		(0.02)	
								1.09***		1.37***		0.47***
New cases								(0.05)		(0.04)		(0.07)
N	1767	1767	961	961	806	806	1767	1767	961	961	806	806
<u>*Panel B: 5 days lag*</u>												
a_{within}	0.20***	0.27***	0.24***	0.29***	0.05	−0.15	0.13***	0.05**	0.10***	−0.04	0.07	−0.18
	(0.01)	(0.02)	(0.02)	(0.04)	(0.09)	(0.18)	(0.01)	(0.02)	(0.02)	(0.03)	(0.09)	(0.18)
a_{acros}	0.01***	0.01***	−0.01	0.00	−0.02	−0.38**	0.00***	0.01**	−0.01	0.02	0.04	−0.38**
	(0.00)	(0.00)	(0.02)	(0.03)	(0.09)	(0.18)	(0.00)	(0.00)	(0.01)	(0.02)	(0.09)	(0.18)
Close contacts							0.27***		0.47***		0.13***	
							(0.01)		(0.02)		(0.02)	
New cases								1.08***		1.37***		0.49***
								(0.04)		(0.04)		(0.07)
N	1705	1705	899	899	806	806	1705	1705	899	899	806	806
<u>*Panel C: 7 days lag*</u>												
a_{within}	0.16***	0.20***	0.24***	0.19***	0.03*	0.15***	0.10***	0.02	0.15***	−0.15***	0.01	0.14***
	(0.02)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)
a_{acros}	−0.00	0.03	−0.01	−0.01	0.00	0.03*	−0.01	0.03*	−0.00	−0.00	−0.00	0.03*
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Close contacts							0.28***		0.47***		0.15***	
							(0.01)		(0.01)		(0.02)	
New cases								1.14***		1.43***		0.57***
								(0.04)		(0.05)		(0.07)
N	1643	1643	837	837	806	806	1643	1643	837	837	806	806
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	×	×	×	×	×	×	×	×	×	×	×	×

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=new cases, *C*=Close contacts.

Table 3. The effects of media coverage on daily spread of COVID−19 across provinces

	T		*T1*		*T2*		*T*		*T1*		*T2*	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
#news, within	1.04***	0.79***	0.20**	0.47***	1.23***	0.77***	0.84***	−0.37***	−0.01	0.20	1.16***	0.29
	(0.05)	(0.11)	(0.09)	(0.16)	(0.08)	(0.17)	(0.05)	(0.12)	(0.08)	(0.14)	(0.08)	(0.20)
#news^2, within	−0.67***	−0.48***	0.04	−0.17	−0.84***	−0.49***	−0.55***	0.27***	0.11*	−0.22*	−0.80***	−0.17
	(0.04)	(0.08)	(0.07)	(0.13)	(0.06)	(0.12)	(0.04)	(0.09)	(0.06)	(0.11)	(0.06)	(0.14)
#news, across	−0.00	0.00	−0.01	−0.02**	−0.00	−0.02**	0.00	−0.02*	−0.01	0.02	0.00	−0.02**
	(0.00)	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)
Close contacts							0.25***		0.44***		0.08***	
							(0.01)		(0.01)		(0.02)	
New cases								1.12***		1.39***		0.39***
								(0.05)		(0.05)		(0.08)
N	1767	1767	961	961	806	806	1767	1767	961	961	806	806
Panel B: 5 days lag												
#news, within	0.85***	0.56***	0.03	0.47***	1.02***	0.70***	0.70***	−0.39***	−0.20**	0.44***	0.94***	0.23
	(0.06)	(0.13)	(0.10)	(0.18)	(0.09)	(0.18)	(0.06)	(0.13)	(0.09)	(0.15)	(0.09)	(0.20)
#news^2, within	−0.55***	−0.37***	0.15*	−0.20	−0.71***	−0.47***	−0.46***	0.25***	0.24***	−0.41***	−0.66***	−0.14
	(0.04)	(0.09)	(0.08)	(0.15)	(0.06)	(0.12)	(0.04)	(0.09)	(0.07)	(0.13)	(0.06)	(0.13)
#news, across	−0.00	−0.10*	−0.01	0.00	0.00	−0.10**	0.02	−0.09*	−0.01	0.01	0.01	−0.10**
	(0.03)	(0.06)	(0.01)	(0.01)	(0.02)	(0.05)	(0.03)	(0.05)	(0.01)	(0.01)	(0.02)	(0.05)
Close contacts							0.27***		0.47***		0.11***	
							(0.01)		(0.01)		(0.02)	
New cases								1.11***		1.40***		0.47***
								(0.05)		(0.04)		(0.07)
N	1705	1705	899	899	806	806	1705	1705	899	899	806	806
Panel C: 7 days lag												
#news, within	0.81***	0.56***	−0.04	0.36*	1.05***	0.85***	0.66***	−0.39***	−0.21**	0.42**	0.95***	0.35*
	(0.06)	(0.12)	(0.12)	(0.21)	(0.09)	(0.18)	(0.06)	(0.12)	(0.10)	(0.18)	(0.09)	(0.20)
#news^2, within	−0.54***	−0.33***	0.20**	−0.18	−0.75***	−0.55***	−0.45***	0.30***	0.28***	−0.47***	−0.69***	−0.19
	(0.04)	(0.09)	(0.10)	(0.17)	(0.06)	(0.13)	(0.04)	(0.09)	(0.08)	(0.15)	(0.06)	(0.14)
#news, across	−0.00	0.02	−0.01	−0.01	0.00	0.02*	−0.01	0.02	0.00	−0.01	−0.00	0.02*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Close contacts							0.28***		0.47***		0.11***	
							(0.01)		(0.01)		(0.02)	
New cases								1.17***		1.46***		0.48***
								(0.05)		(0.05)		(0.07)
N	1643	1643	837	837	806	806	1643	1643	837	837	806	806
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=new cases, *C*=Close contacts.

Table 4. The effects of within− and across−province population movement on daily spread of COVID−19

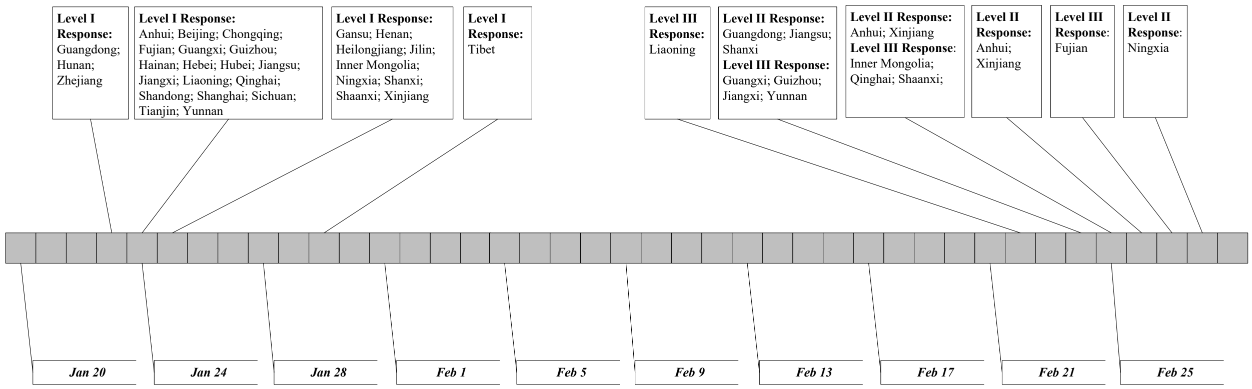
	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
<u>*Panel A: 3 days lag*</u>												
inner movement, within	0.14***	0.23***	0.30***	0.21	0.09***	0.15**	0.08***	0.02	0.21***	−0.38***	0.06**	0.10
	(0.03)	(0.06)	(0.08)	(0.17)	(0.03)	(0.06)	(0.02)	(0.06)	(0.06)	(0.13)	(0.03)	(0.06)
population inflow, within	0.17***	0.05	0.09	0.24*	0.09***	−0.03	0.15***	−0.21***	−0.02	0.07	0.10***	−0.09
	(0.03)	(0.06)	(0.06)	(0.13)	(0.03)	(0.06)	(0.02)	(0.06)	(0.04)	(0.09)	(0.03)	(0.06)
population inflow, across	0.01	−0.03*	0.01***	0.01	0.00	−0.03**	0.01**	−0.04**	0.00**	−0.01**	0.01	−0.03**
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.01)
Close contacts							0.28***		0.44***		0.17***	
							(0.01)		(0.01)		(0.02)	
New cases								1.51***		1.95***		0.67***
								(0.06)		(0.05)		(0.09)
N	1153	1153	677	677	476	476	1153	1153	677	677	476	476
<u>*Panel B: 5 days lag*</u>												
inner movement, within	0.11***	0.19***	0.07	0.01	0.07***	0.14**	0.05**	0.03	0.06	−0.11	0.05*	0.09
	(0.03)	(0.06)	(0.09)	(0.17)	(0.03)	(0.05)	(0.02)	(0.05)	(0.07)	(0.13)	(0.03)	(0.05)
population inflow, within	0.10***	0.03	−0.01	0.13	0.04	0.03	0.09***	−0.12**	−0.07	0.15	0.04	0.00
	(0.03)	(0.06)	(0.07)	(0.13)	(0.03)	(0.06)	(0.02)	(0.05)	(0.05)	(0.10)	(0.03)	(0.06)
population inflow, across	0.01	−0.04	0.01*	−0.00	0.00	−0.06**	0.03**	−0.06**	0.01**	−0.01**	0.01	−0.06**
	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)	(0.03)	(0.01)	(0.03)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.32***		0.48***		0.19***	
							(0.01)		(0.01)		(0.02)	
New cases								1.47***		1.79***		0.69***
								(0.05)		(0.05)		(0.09)
N	1127	1127	673	673	454	454	1127	1127	673	673	454	454
<u>*Panel C: 7 days lag*</u>												
inner movement, within	0.13***	0.28***	−0.13	−0.35	0.10***	0.19***	0.04	0.10*	0.04	−0.14	0.06*	0.12**
	(0.03)	(0.06)	(0.12)	(0.22)	(0.03)	(0.06)	(0.03)	(0.06)	(0.10)	(0.17)	(0.03)	(0.06)
population inflow, within	0.07**	−0.08	0.03	0.21*	0.02	−0.04	0.09***	−0.17***	−0.08	0.16*	0.03	−0.05
	(0.03)	(0.06)	(0.07)	(0.12)	(0.04)	(0.06)	(0.03)	(0.06)	(0.05)	(0.10)	(0.03)	(0.06)
population inflow, across	0.02	−0.03	−0.00	−0.00	0.01	−0.03	0.03**	−0.05**	−0.00	0.00	0.02	−0.04*
	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.32***		0.50***		0.20***	
							(0.01)		(0.01)		(0.03)	
New cases								1.35***		1.59***		0.67***
								(0.05)		(0.05)		(0.08)
N	1096	1096	664	664	432	432	1096	1096	664	664	432	432
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=new cases, *C*=Close contacts.

Table 5. The direct and mediating effects of media coverage on daily spread of COVID−19 across provinces

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
<u>*Panel A: 3 days lag*</u>												
#news, within	1.18***	1.32***	−1.67***	−0.59	1.27***	1.27***	0.84***	−0.40	−1.41***	2.69***	1.13***	0.66**
	(0.10)	(0.25)	(0.42)	(0.88)	(0.14)	(0.29)	(0.10)	(0.25)	(0.30)	(0.64)	(0.14)	(0.31)
#news^2, within	−0.77***	−0.80***	1.23***	0.73	−0.85***	−0.79***	−0.57***	0.33**	0.91***	−1.69***	−0.76***	−0.38*
	(0.07)	(0.17)	(0.29)	(0.62)	(0.09)	(0.19)	(0.07)	(0.17)	(0.21)	(0.45)	(0.09)	(0.20)
#news, across	0.00	−0.00	0.01	0.09*	0.01	−0.01	0.01	−0.01	−0.03	0.07*	0.01	−0.01
	(0.01)	(0.01)	(0.02)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)	(0.01)	(0.01)
inner movement, within	0.02	0.02	0.38***	−0.17	−0.00	0.01	0.02	−0.01	0.46***	−0.92***	−0.00	0.01
	(0.03)	(0.07)	(0.11)	(0.23)	(0.03)	(0.06)	(0.03)	(0.06)	(0.08)	(0.17)	(0.03)	(0.06)
population inflow, within	−0.00	−0.21***	0.32***	0.11	−0.03	−0.21***	0.05*	−0.21***	0.27***	−0.51***	−0.01	−0.19***
	(0.03)	(0.07)	(0.10)	(0.20)	(0.04)	(0.07)	(0.03)	(0.07)	(0.07)	(0.15)	(0.04)	(0.07)
population inflow, across	−0.00	−0.02	0.01***	0.01**	−0.01	−0.02	0.00	−0.02	0.00	−0.00	−0.00	−0.01
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.25***		0.44***		0.11***	
							(0.01)		(0.01)		(0.02)	
New cases								1.46***		1.96***		0.48***
								(0.06)		(0.05)		(0.09)
N	1153	1153	677	677	476	476	1153	1153	677	677	476	476
<u>*Panel B: 5 days lag*</u>												
#news, within	0.77***	1.19***	−0.16	−0.26	0.98***	1.39***	0.41***	0.11	−0.04	0.02	0.78***	0.84***
	(0.11)	(0.24)	(0.42)	(0.81)	(0.15)	(0.29)	(0.11)	(0.23)	(0.32)	(0.61)	(0.15)	(0.30)
#news^2, within	−0.49***	−0.71***	0.29	0.58	−0.67***	−0.87***	−0.27***	−0.02	0.02	0.07	−0.54***	−0.50**
	(0.08)	(0.16)	(0.30)	(0.59)	(0.10)	(0.20)	(0.07)	(0.15)	(0.23)	(0.45)	(0.10)	(0.20)
#news, across	0.01	−0.02	−0.05***	−0.07***	0.01	−0.02	0.01*	−0.03*	−0.02**	0.02	0.01	−0.02
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
inner movement, within	0.02	−0.02	−0.09	−0.33*	0.02	−0.01	0.03	−0.05	0.06	−0.16	0.02	−0.02
	(0.03)	(0.06)	(0.10)	(0.19)	(0.03)	(0.06)	(0.03)	(0.06)	(0.08)	(0.15)	(0.03)	(0.06)
population inflow, within	−0.02	−0.22***	−0.22*	−0.29	−0.04	−0.14**	0.05*	−0.19***	−0.08	0.09	−0.02	−0.12*
	(0.03)	(0.07)	(0.11)	(0.22)	(0.03)	(0.07)	(0.03)	(0.06)	(0.09)	(0.17)	(0.03)	(0.06)
population inflow, across	0.01	−0.03	−0.00	−0.01	−0.00	−0.05**	0.02*	−0.04*	0.00	−0.00	0.01	−0.04**
	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.30***		0.47***		0.15***	
							(0.01)		(0.01)		(0.02)	
New cases								1.40***		1.77***		0.55***
								(0.06)		(0.05)		(0.09)
N	1127	1127	673	673	454	454	1127	1127	673	673	454	454
<u>*Panel C: 7 days lag*</u>												
#news, within	0.84***	0.88***	−0.83*	−1.17	1.17***	1.03***	0.57***	−0.25	−0.24	0.12	1.01***	0.32
	(0.12)	(0.26)	(0.48)	(0.86)	(0.17)	(0.32)	(0.12)	(0.24)	(0.39)	(0.69)	(0.17)	(0.34)
#news^2, within	−0.55***	−0.55***	0.84**	1.43**	−0.82***	−0.69***	−0.38***	0.19	0.13	0.12	−0.70***	−0.20
	(0.08)	(0.17)	(0.40)	(0.70)	(0.11)	(0.22)	(0.08)	(0.16)	(0.32)	(0.56)	(0.11)	(0.23)
#news, across	0.03	−0.03	0.01***	0.02***	0.01	−0.03	0.04*	−0.07*	0.00	0.00**	0.02	−0.04
	(0.02)	(0.04)	(0.00)	(0.00)	(0.02)	(0.04)	(0.02)	(0.04)	(0.00)	(0.00)	(0.02)	(0.04)
inner movement, within	0.06*	0.12*	−0.31**	−0.81***	0.05	0.10	0.02	0.04	0.10	−0.33*	0.04	0.06
	(0.03)	(0.07)	(0.13)	(0.24)	(0.03)	(0.07)	(0.03)	(0.07)	(0.11)	(0.19)	(0.03)	(0.07)
population inflow, within	0.02	−0.31**	−0.01	−0.05	−0.04	−0.21*	0.11**	−0.33***	0.02	−0.03	−0.00	−0.19*
	(0.06)	(0.13)	(0.11)	(0.19)	(0.06)	(0.11)	(0.06)	(0.12)	(0.09)	(0.15)	(0.06)	(0.11)
population inflow, across	0.07	−0.09	−0.01***	−0.02***	0.03	−0.09	0.10**	−0.18*	−0.00	−0.00	0.04	−0.11
	(0.05)	(0.11)	(0.00)	(0.01)	(0.05)	(0.09)	(0.05)	(0.10)	(0.00)	(0.01)	(0.05)	(0.09)
Close contacts							0.31***		0.50***		0.16***	
							(0.01)		(0.02)		(0.02)	
New cases								1.34***		1.56***		0.60***
								(0.05)		(0.05)		(0.09)
N	1096	1096	664	664	432	432	1096	1096	664	664	432	432
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=new cases, *C*=Close contacts.



Note: In China, public health emergencies, including infectious disease epidemics, can be categorized into four levels, with Level I being the highest level of mobilization.

Figure 1. Activation of Public Health Emergency Responses by Provinces

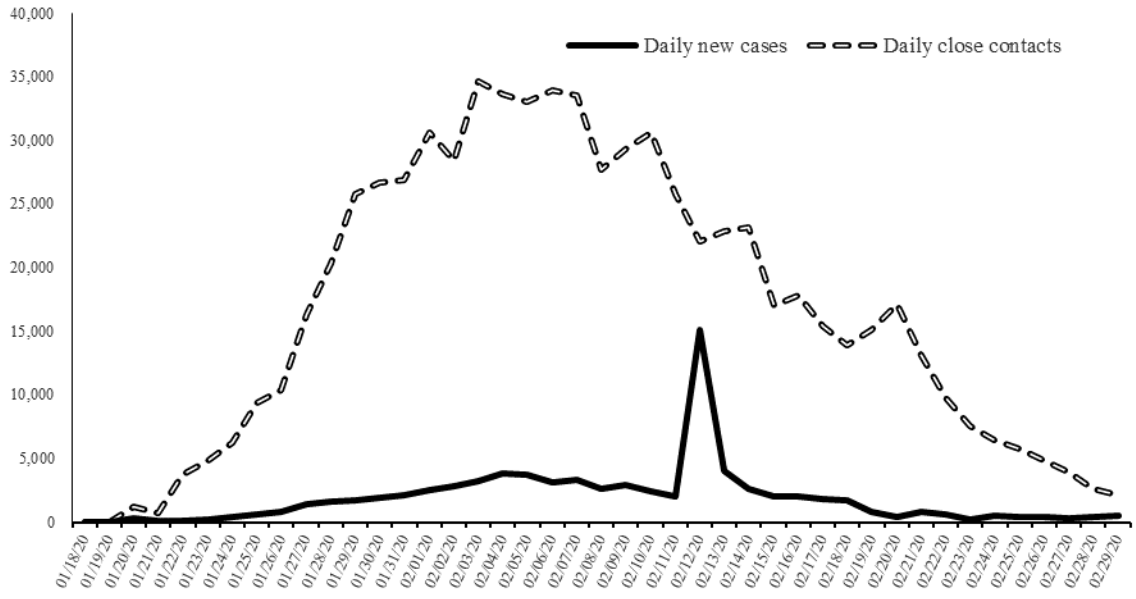


Figure 2. Daily Numbers of COVID-19 New Cases and Close Contacts in Mainland China

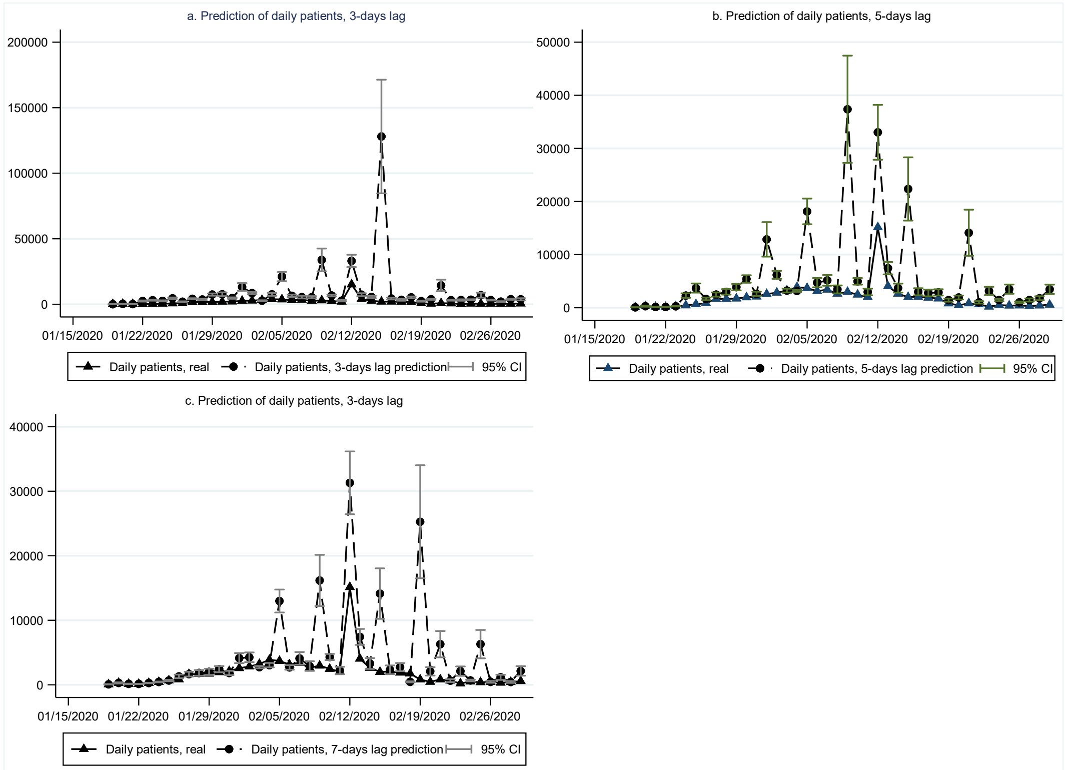


Figure 3. Counterfactual Policy Simulations for COVID-19 New Cases

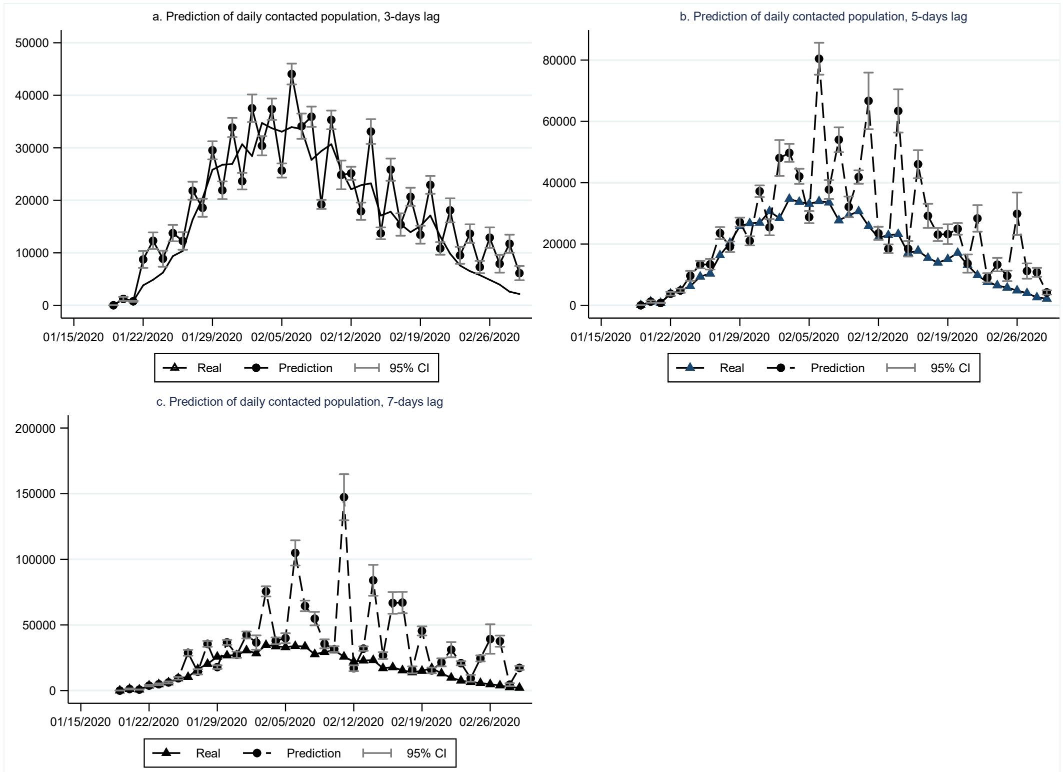


Figure 4. Counterfactual Policy Simulations for Close Contacts Identified

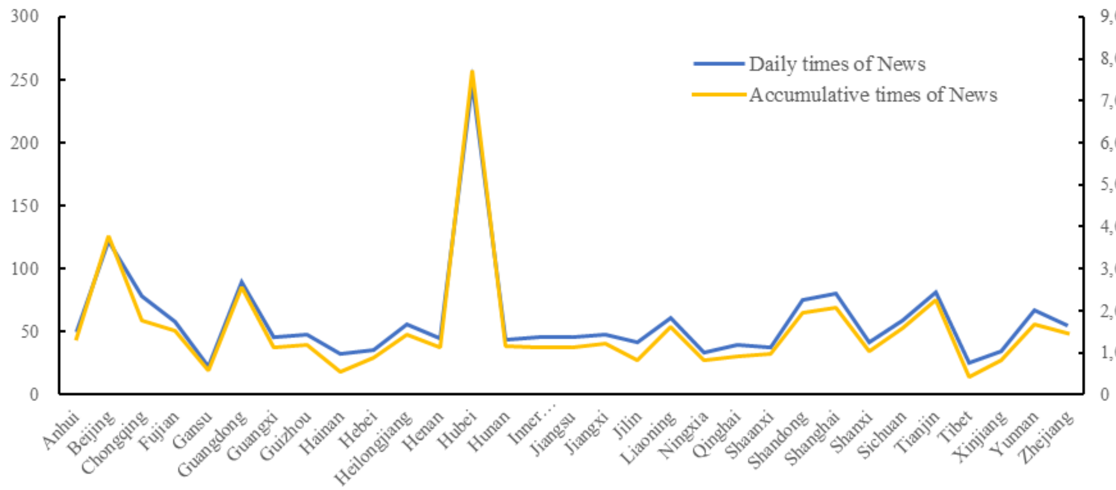
Appendix A: Measurement of Media Exposure

DXY (http://www.dxy.cn/) is a leading connector and digital service provider in the healthcare industry of China. Throughout the past 19 years, DXY has built a leading online forum for physicians, launched a series of mobile applications, opened its wholly-owned clinics. DXY's services include a professional information sharing platform, comprehensive data stewardship and management, high-quality medical services, which connect hospitals, physicians, researchers, patients, pharma, and insurance payers. By the end of 2016, DXY has tens of millions of public users in China, and more than 5.5 million registered allied health professionals, including 2 million physicians. DXY has opened DingXiang Family Clinics in Hangzhou and Fuzhou, with plans for a continuing expansion to metropolitan cities in the near future.

The data platform of DXY (https://ncov.dxy.cn/ncovh5/view/pneumonia) collects and updates all data about COVID-19, including regional distribution of cases, as well as news. Particularly, they timely gather official news about COVID-19 from the website, WeChat Official Account (A product of Tencent Inc and used by many governmental agencies to announce certain policies and information) of local and central authorities, and official media including newspapers and TV. If the same news was reported by different sources, they keep only one source. The news reports include all the information on COVID-19 released by the government. Data fields collected include release time, title, summary, information source with uniform resource locator, and province.

The first news release was published on December 31, 2019, showing that 27 pneumonia cases were confirmed in Wuhan. During our study period, 7321 news reports and releases on COVID-19 were published. We excluded the news about COVID-19 for foreign countries, and for Taiwan, Hongkong, and Macau. We further categorized the remained news by province and date. The central government also disclose information about COVID-19, and we excluded them if they did not mention a specific province which we categorized into the provincial group. We have a final dataset of 1849 news releases and reports for 31 provinces.

To proxy the media exposure, we calculated the number of news releases and reports about COVID-19 for every province each day, i.e., "daily # news". Then, we calculated the "cumulative number of news reports and releases" about COVID-19 for every province each day: the number on day 1 equals the number on day 1, the number on day 2 equals the sum of the numbers on day 1 and day 2, the number of news releases and reports on day t equals the number on day t plus the number on the prior day (t-1), and so on. The provincial variation of daily times of news and accumulative times of news can be found in the Figure A1, and a detailed summary statistic is presented in Table A1.



1. The right vertical axis represents the range of accumulative times of news, and the left vertical axis measures the daily times of news.

Appendix Figure A1. The provincial variation of the daily number of news reports and the cumulative number of news reports

Appendix Table A1. The Summary of the number of news reports and releases

Province	Daily number of news reports						Cumulative number of news reports					
	Obs	Times	Mean	SD	Min	Max	Obs	Times	Mean	SD	Min	Max
Anhui	36	50	1.39	0.77	1	5	42	1342	31.95	14.79	2	50
Beijing	44	122	2.77	2.73	1	13	45	3771	83.80	34.71	2	122
Chongqing	42	78	1.86	1.20	1	6	43	1761	40.95	25.52	1	78
Fujian	38	58	1.53	0.98	1	5	42	1531	36.45	16.97	1	58
Gansu	19	22	1.16	0.37	1	2	40	574	14.35	5.55	2	22
Guangdong	37	90	2.43	1.71	1	8	44	2572	58.45	28.77	2	90
Guangxi	37	46	1.24	0.60	1	3	42	1118	26.62	12.93	1	46
Guizhou	37	48	1.30	0.52	1	3	43	1174	27.30	15.10	1	48
Hainan	21	33	1.57	0.68	1	3	27	535	19.81	10.39	1	33
Hebei	31	36	1.16	0.37	1	2	42	872	20.76	10.87	1	36
Heilongjiang	37	56	1.51	0.73	1	3	43	1424	33.12	17.07	1	56
Henan	35	45	1.29	0.52	1	3	43	1134	26.37	13.41	1	45
Hubei	54	247	4.57	4.24	1	17	65	7741	119.09	95.39	1	247
Hunan	33	44	1.33	0.65	1	3	42	1153	27.45	13.13	2	44
Inner Mongolia	34	46	1.35	0.69	1	3	41	1133	27.63	12.88	1	46
Jiangsu	36	46	1.28	0.51	1	3	41	1123	27.39	13.99	2	46
Jiangxi	34	48	1.41	0.74	1	4	42	1229	29.26	13.75	1	48
Jilin	32	42	1.31	0.69	1	4	36	824	22.89	11.65	1	42
Liaoning	42	61	1.86	1.20	1	6	43	1626	40.95	25.52	1	78
Ningxia	28	34	1.21	0.50	1	3	42	831	19.79	10.89	1	34
Qinghai	30	40	1.33	0.61	1	3	40	909	22.73	12.46	1	40
Shaanxi	30	38	1.27	0.64	1	4	41	983	23.98	10.01	2	38
Shandong	37	75	2.03	1.42	1	8	41	1962	47.85	21.45	2	75
Shanghai	41	80	1.95	1.09	1	5	44	2084	47.36	25.70	1	80
Shanxi	29	42	1.45	0.69	1	3	42	1030	24.52	12.50	1	42
Sichuan	39	59	1.51	0.88	1	5	43	1579	36.72	17.07	1	59
Tianjin	34	81	2.38	1.61	1	6	43	2247	52.26	25.87	1	81
Tibet	21	25	1.19	0.40	1	2	32	422	13.19	7.16	1	25
Xinjiang	31	35	1.13	0.34	1	2	41	832	20.29	10.21	1	35
Yunnan	36	67	1.86	0.99	1	5	42	1666	39.67	20.00	1	67
Zhejiang	35	55	1.57	0.81	1	3	47	1468	31.23	17.49	1	55
Total	1064	1849	1.74	1.58	1	17	1304	48650	37.31	35.85	1	247

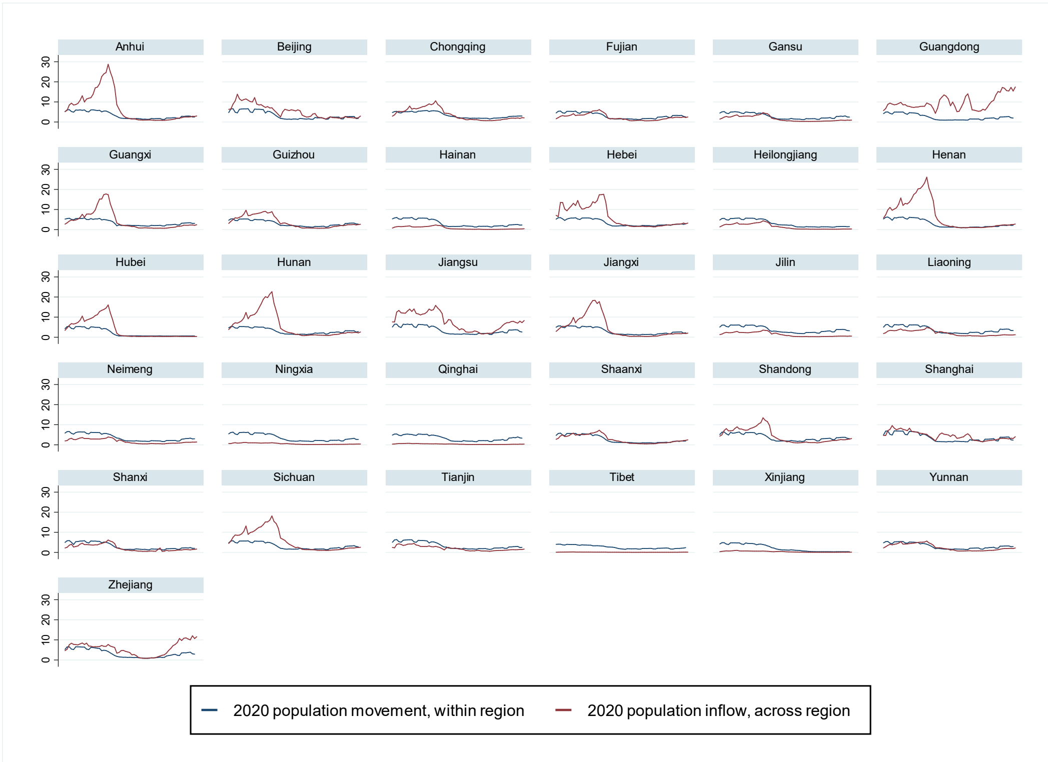
1. *N*=sample size; 2. Daily number of news reports are the total number of official news reports and releases in one day for every province, and the accumulative number of news reports the cumulative number of daily news reports and releases each day.

Appendix Table A2. The relation between the number of news reports and the spread of COVID-19

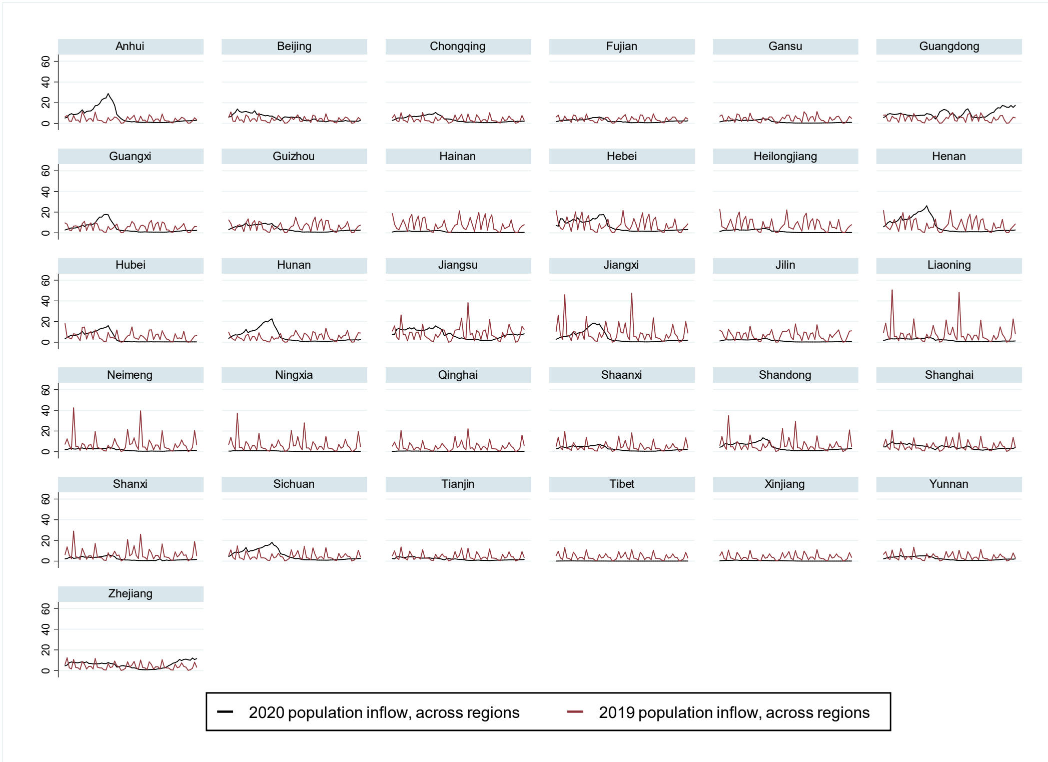
	Daily identified patients	Daily contacted population
Panel A: with Hubei		
#news	0.22	0.31
	(0.47)	(0.61)
#new ^{2}	0.02	-0.15
	(0.06)	(0.11)
N	1243	1243
R^2	0.75	0.55
Panel B: without Hubei		
#news	0.89***	1.12*
	(0.20)	(0.63)
#news ^{2}	-0.09**	-0.29*
	(0.04)	(0.15)
N	1183	1183
R^2	0.71	0.48

1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01.

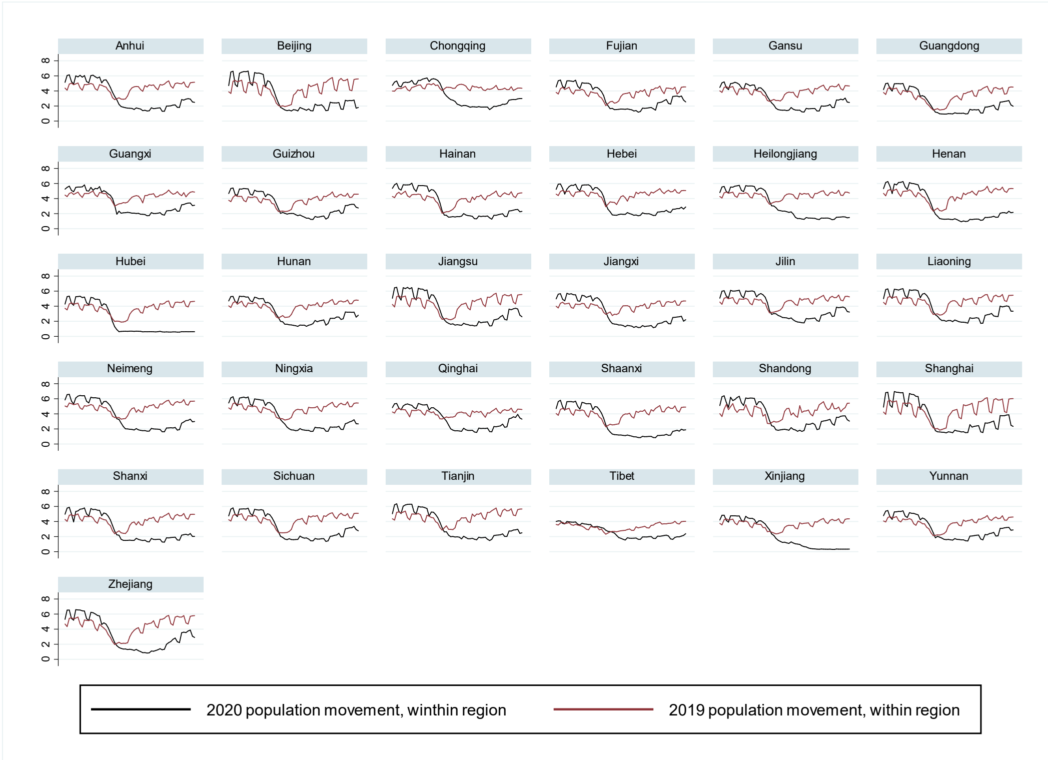
Appendix B. Population Mobility by Province



Appendix Figure B1. Plots of the variation for population inflow and movement in every province



Appendix Figure B2. Plots of the variation for population inflow for every province in 2019 and 2020



Appendix Figure B3. Plots of the variation for within population movement for every province in 2019 and 2020

Appendix C: Description and summary of key variables

Appendix Table C1. Descriptions of the key variables

Variable	Description
Epidemic	
Daily patients	The daily number of new patients with COVID-19 for each province.
Daily contacted population	The daily number of individuals who had been in close contact with CO VID-19 patients in each province.
Information Openness	
#news	The daily cumulated number of officially news releases and reports about COVID-19 in every province.
Population Mobility	
Index of population inflow, 2020	Daily index of population inflow for every province which indicates the population inflowed from other province to the target province in 2020.
Index of population inflow, 2019	Daily index of population inflow for every province which indicates the population inflowed from other province to the target province in 2019.
Index of inner population movement, 2020	Daily index of inner population movement for every province which indicates the inner population movement for target province in 2020.
Index of inner population movement, 2019	Daily index of inner population movement for every province which indicates the inner population movement for target province in 2020.
Controls	
Wind level	The level of daily wind for every province.
Rain	0=None, 1=Rian, 2=Snow.
Temperature	The daily average temperature for every province.
Population size (million)	The whole population size for every province.
Area (10 thousand KM^2)	The whole area for every province in kilometer squared.

Appendix Table C2. Summary statistics of the key variables

Variable	Obs	Mean	SD	Min	Max
Epidemic					
Daily patients	1,863	43.05	418.07	0.00	14840.00
Daily contacted population	1,863	384.65	1203.03	0.00	12900.00
Information Openness					
#news (number of news reports and releases)	1,860	23.55	32.45	0.00	236.00
Population Mobility					
Index of population inflow, 2020	1,891	3.17	1.72	0.30	6.96
Index of population inflow, 2019	1,891	4.21	0.83	1.47	6.15
Index of inner population movement, 2020	1,922	3.62	4.25	0.04	28.75
Index of inner population movement, 2019	1,922	5.63	5.23	0.08	50.61
Controls					
Wind level	1,916	2.70	1.12	2.00	7.00
Rain	1,916	0.27	0.55	0.00	2.00
Temperature	1,916	4.07	8.66	-23.50	25.50
Population size (million)	1,860	46.79	27.65	3.44	113.46
Area (10 thousand KM^2)	1,860	31.00	38.12	0.63	166.00

Appendix D: Supplemental results for econometric specification

Appendix Table D1. Daily spread of COVID-19 within province excluding Hubei

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
$a_{within,}$	0.19***	0.24***	0.28***	0.34***	0.10***	0.16***	0.17***	0.01	0.15***	−0.08***	0.08***	0.12***
	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)
Close contacts							0.26***		0.44***		0.12***	
							(0.01)		(0.01)		(0.02)	
New cases								1.09***		1.37***		0.47***
								(0.05)		(0.04)		(0.07)
N	1710	1710	930	930	780	780	1767	1767	961	961	806	806
Panel B: 5 days lag												
a_{within}	0.15***	0.24***	0.24***	0.31***	0.06***	0.22***	0.13***	0.05*	0.11***	−0.06**	0.03**	0.20***
	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
Close contacts							0.27***		0.47***		0.13***	
							(0.01)		(0.02)		(0.02)	
New cases								1.08***		1.37***		0.49***
								(0.04)		(0.04)		(0.07)
N	1650	1650	870	870	780	780	1705	1705	899	899	806	806
Panel C: 7 days lag												
a_{within}	0.12***	0.15***	0.26***	0.25***	0.12***	0.11***	0.11***	−0.01	0.15***	−0.14***	0.01	0.10***
	(0.02)	(0.03)	(0.04)	(0.04)	(0.02)	(0.04)	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.04)
Close contacts							0.28***		0.47***		0.15***	
							(0.01)	1.14***	(0.01)	1.43***	(0.02)	0.57***
New cases								(0.04)		(0.05)		(0.07)
N	1590	1590	810	810	780	780	1643	1643	837	837	806	806
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	×	×	×	×	×	×	×	×	×	×	×	×

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=New cases, *C*=Close contacts.

Appendix Table D2. Spread of COVID-19 across provinces, excluding Hubei

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
a_{within}	0.18***	0.19***	0.27***	0.34***	0.10***	0.12***	0.14***	−0.01	0.13***	−0.07*	0.08***	0.07**
	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)
a_{acros}	−0.01	−0.04**	−0.01	0.00	−0.01	−0.04**	0.00	−0.03*	−0.01	0.02	−0.00	−0.04**
	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.02)
Close contacts							0.21***		0.40***		0.12***	
							(0.01)		(0.01)		(0.02)	
New cases								1.13***		1.54***		0.50***
								(0.05)		(0.05)		(0.07)
N	1710	1710	930	930	780	780	1710	1710	930	930	780	780
Panel B: 5 days lag												
a_{within}	0.16***	0.25***	0.24***	0.32***	0.04	−0.17	0.11***	0.07***	0.10***	−0.04	0.07	−0.20
	(0.01)	(0.02)	(0.02)	(0.04)	(0.10)	(0.19)	(0.01)	(0.02)	(0.02)	(0.04)	(0.10)	(0.19)
a_{acros}	0.01***	0.02***	−0.01	0.00	−0.02	−0.39**	0.01***	0.00*	−0.01	0.02	0.03	−0.38**
	(0.00)	(0.00)	(0.01)	(0.03)	(0.10)	(0.18)	(0.00)	(0.00)	(0.01)	(0.02)	(0.09)	(0.18)
Close contacts							0.22***		0.42***		0.14***	
							(0.01)		(0.01)		(0.02)	
New cases								1.11***		1.52***		0.52***
								(0.05)		(0.05)		(0.07)
N	1650	1650	870	870	780	780	1650	1650	870	870	780	780
Panel C: 3 days lag												
a_{within}	0.12***	0.19***	0.25***	0.23***	0.03	0.14***	0.08***	0.04	0.15***	−0.16***	0.01	0.12***
	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)
a_{acros}	−0.00	0.03	−0.01	−0.02	0.00	0.03*	−0.01	0.03*	−0.00	−0.00	−0.00	0.03*
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Close contacts							0.23***		0.42***		0.15***	
							(0.01)		(0.01)		(0.02)	
New cases								1.17***		1.59***		0.60***
								(0.05)		(0.05)		(0.07)
N	1590	1590	810	810	780	780	1590	1590	810	810	780	780
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	×	×	×	×	×	×	×	×	×	×	×	×

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. *T*=the full sample, T_1=subsample with data before Feb 5, T_2=subsample with data after Feb 5; 4. *R*=New cases, *C*=Close contacts.

Appendix Table D3. The effects of media coverage on spread of COVID-19 across provinces, excluding Hubei

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
<u>*Panel A: 3 days lag*</u>												
#news, within	1.03***	0.81***	0.69***	0.83***	1.24***	0.78***	0.88***	−0.38***	0.36***	−0.24	1.17***	0.27
	(0.05)	(0.12)	(0.09)	(0.17)	(0.08)	(0.18)	(0.05)	(0.13)	(0.08)	(0.16)	(0.08)	(0.20)
#news², within	−0.69***	−0.51***	−0.39***	−0.46***	−0.85***	−0.51***	−0.59***	0.28***	−0.21***	0.15	−0.80***	−0.16
	(0.03)	(0.09)	(0.07)	(0.14)	(0.06)	(0.12)	(0.03)	(0.09)	(0.06)	(0.13)	(0.06)	(0.14)
#news, across	−0.00	−0.02**	−0.01	0.00	−0.00	−0.02**	0.00	−0.02*	−0.01	0.01	0.00	−0.02**
	(0.00)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.02)	(0.00)	(0.01)
Close contacts							0.19***		0.40***		0.09***	
							(0.01)		(0.01)		(0.02)	
New cases								1.15***		1.55***		0.41***
								(0.06)		(0.05)		(0.08)
N	1710	1710	930	930	780	780	1710	1710	930	930	780	780
<u>*Panel B: 5 days lag*</u>												
#news, within	0.88***	0.61***	0.55***	0.87***	1.04***	0.67***	0.75***	−0.40***	0.18**	0.04	0.96***	0.15
	(0.06)	(0.14)	(0.10)	(0.19)	(0.09)	(0.19)	(0.06)	(0.14)	(0.09)	(0.17)	(0.09)	(0.20)
#news², within	−0.59***	−0.41***	−0.30***	−0.52***	−0.72***	−0.46***	−0.51***	0.26***	−0.08	−0.07	−0.67***	−0.09
	(0.04)	(0.09)	(0.08)	(0.16)	(0.06)	(0.13)	(0.04)	(0.09)	(0.07)	(0.14)	(0.06)	(0.14)
#news, across	0.00	−0.10*	−0.00	0.00	0.00	−0.10**	0.02	−0.10*	−0.01	0.01	0.01	−0.10**
	(0.02)	(0.06)	(0.01)	(0.01)	(0.02)	(0.05)	(0.02)	(0.05)	(0.01)	(0.01)	(0.02)	(0.05)
Close contacts							0.21***		0.42***		0.12***	
							(0.01)		(0.01)		(0.02)	
New cases								1.14***		1.52***		0.50***
								(0.05)		(0.05)		(0.07)
N	1650	1650	870	870	780	780	1650	1650	870	870	780	780
<u>*Panel C: 7 days lag*</u>												
#news, within	0.86***	0.60***	0.51***	0.81***	1.07***	0.79***	0.73***	−0.44***	0.17	−0.01	0.98***	0.23
	(0.06)	(0.13)	(0.12)	(0.23)	(0.09)	(0.19)	(0.05)	(0.13)	(0.10)	(0.20)	(0.09)	(0.21)
#news², within	−0.60***	−0.37***	−0.27***	−0.54***	−0.77***	−0.51***	−0.52***	0.35***	−0.04	−0.11	−0.71***	−0.11
	(0.04)	(0.10)	(0.10)	(0.20)	(0.06)	(0.13)	(0.04)	(0.10)	(0.09)	(0.17)	(0.06)	(0.14)
#news, across	0.00	0.02	−0.01	−0.02	0.00	0.02*	−0.00	0.02	−0.00	−0.00	−0.00	0.02*
	(0.01)	0.60***	(0.01)	0.81***	(0.01)	0.79***	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Close contacts							0.22***		0.43***		0.11***	
							(0.01)		(0.01)		(0.02)	
New cases								1.21***		1.58***		0.52***
								(0.05)		(0.05)		(0.08)
N	1590	1590	810	810	780	780	1590	1590	810	810	780	780
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. T=the full sample, T1=subsample with data before Feb 5, T2=subsample with data after Feb 5; 4. R=New cases, C=Close contacts.

Appendix Table D4. The effects of within- and across-provinces population mobility on spread of COVID-19, excluding Hubei

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
inner movement, within	0.13***	0.22***	0.17**	0.22	0.09***	0.15**	0.08***	0.00	0.08	−0.15	0.07**	0.09
	(0.02)	(0.06)	(0.08)	(0.17)	(0.03)	(0.06)	(0.02)	(0.06)	(0.05)	(0.11)	(0.03)	(0.06)
population inflow, within	0.09***	−0.02	0.06	0.24**	0.09**	−0.03	0.09***	−0.16***	−0.04	0.10	0.09***	−0.09
	(0.02)	(0.06)	(0.05)	(0.12)	(0.03)	(0.07)	(0.02)	(0.06)	(0.03)	(0.08)	(0.03)	(0.07)
population inflow, across	0.00	−0.03**	0.01***	0.01	0.00	−0.03**	0.01	−0.03**	0.00***	−0.01***	0.01	−0.03**
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.24***		0.43***		0.18***	
							(0.01)		(0.01)		(0.02)	
New cases								1.66***		2.18***		0.68***
								(0.07)		(0.04)		(0.09)
N	1132	1132	663	663	469	469	1132	1132	663	663	469	469
Panel B: 5 days lag												
inner movement, within	0.11***	0.19***	0.46***	0.57**	0.08***	0.13**	0.06***	0.02	0.21***	−0.36**	0.05*	0.08
	(0.02)	(0.06)	(0.10)	(0.22)	(0.03)	(0.06)	(0.02)	(0.05)	(0.07)	(0.16)	(0.03)	(0.06)
population inflow, within	0.05**	−0.00	0.02	0.21	0.04	0.03	0.05**	−0.08	−0.07	0.16	0.03	0.00
	(0.02)	(0.06)	(0.06)	(0.14)	(0.03)	(0.06)	(0.02)	(0.06)	(0.05)	(0.10)	(0.03)	(0.06)
population inflow, across	0.00	−0.05*	0.01**	0.00	0.00	−0.06**	0.02	−0.06**	0.01***	−0.01***	0.01	−0.06**
	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)	(0.03)	(0.01)	(0.03)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.26***		0.43***		0.19***	
							(0.01)		(0.01)		(0.02)	
New cases								1.59***		2.03***		0.71***
								(0.07)		(0.05)		(0.09)
N	1105	1105	658	658	447	447	1105	1105	658	658	447	447
Panel C: 7 days lag												
inner movement, within	0.12***	0.27***	0.18	0.11	0.11***	0.19***	0.04*	0.10*	0.13	−0.20	0.07**	0.11*
	(0.03)	(0.06)	(0.13)	(0.24)	(0.03)	(0.06)	(0.03)	(0.06)	(0.10)	(0.19)	(0.03)	(0.06)
population inflow, within	0.03	−0.11*	0.19***	0.47***	0.02	−0.04	0.06**	−0.15***	−0.02	0.13	0.02	−0.05
	(0.03)	(0.06)	(0.07)	(0.14)	(0.04)	(0.07)	(0.03)	(0.06)	(0.06)	(0.11)	(0.04)	(0.06)
population inflow, across	0.01	−0.04	−0.01***	−0.01	0.01	−0.03	0.02*	−0.05**	−0.00*	0.01	0.02	−0.04*
	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)
Close contacts							0.28***		0.47***		0.20***	
							(0.01)		(0.01)		(0.03)	
New cases								1.42***		1.73***		0.68***
								(0.06)		(0.05)		(0.09)
N	1075	1075	650	650	425	425	1075	1075	650	650	425	425
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. T=the full sample, T1=subsample with data before Feb 5, T2=subsample with data after Feb 5; 4. R=New cases, C=Close contacts.

Appendix Table D5. The effects of media coverage on within− and across−province population movement

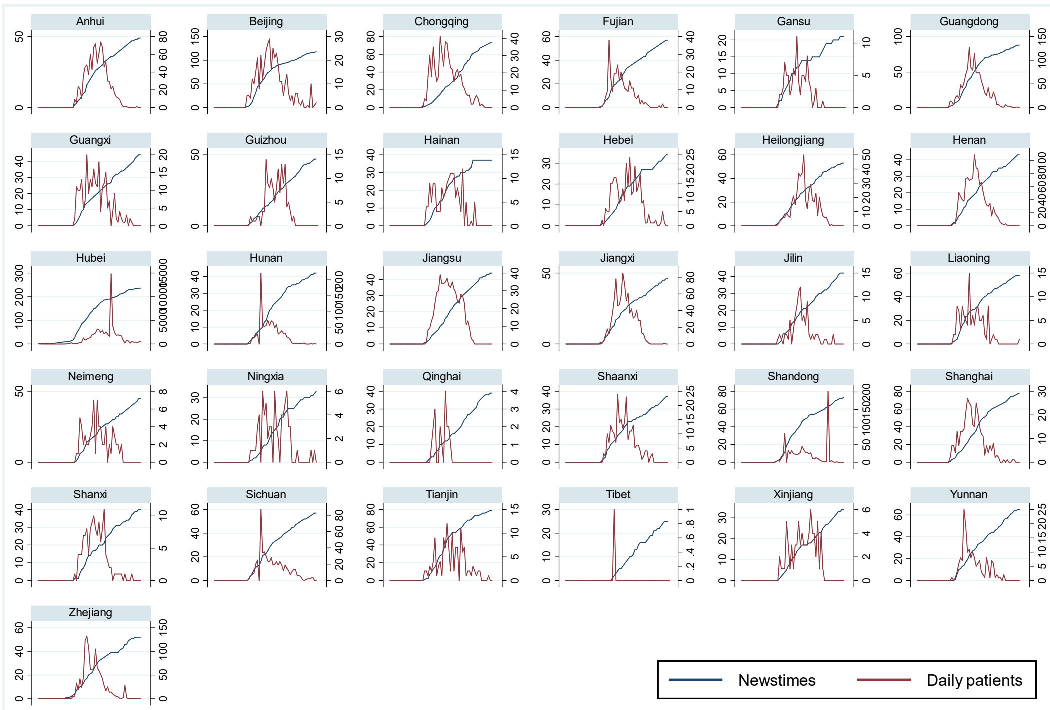
	Population inflow, across provinces			Population movement, within province		
	(1)	(2)	(3)	(4)	(5)	(6)
<u>*Panel A: within province model*</u>						
#news	−0.019	−0.043**	−0.014	−0.004**	−0.016**	−0.003
	(0.012)	(0.019)	(0.012)	(0.002)	(0.006)	(0.009)
N	1860	930	930	1860	930	930
<u>*Panel B: across provinces model*</u>						
#news, within	−0.0118	−0.042**	−0.013	−0.005***	−0.021***	−0.002
	(0.012)	(0.018)	(0.011)	(0.002)	(0.006)	(0.009)
#news, across	0.001	0.001	0.001*	−0.001***	−0.004***	0.001**
	(0.004)	(0.008)	(0.005)	(0.001)	(0.002)	(0.003)
N	1860	930	930	1860	930	930
Province FE	√	√	√	√	√	√
Date FE	√	√	√	√	√	√
Controls	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table D6. The direct and mediating effects of media coverage across provinces, excluding Hubei

	T		T_1		T_2		T		T_1		T_2	
	R	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*	*R*	*C*
Panel A: 3 days lag												
#news, within	0.92***	1.13***	−0.57	−0.54	1.30***	1.25***	0.67***	−0.37	−0.33	0.69	1.15***	0.60*
	(0.09)	(0.25)	(0.44)	(0.99)	(0.14)	(0.29)	(0.09)	(0.25)	(0.28)	(0.62)	(0.14)	(0.31)
#news^2, within	−0.61***	−0.68***	0.49	0.69	−0.87***	−0.79***	−0.46***	0.31*	0.19	−0.37	−0.78***	−0.35*
	(0.06)	(0.17)	(0.31)	(0.69)	(0.09)	(0.19)	(0.06)	(0.17)	(0.19)	(0.43)	(0.09)	(0.21)
#news, across	0.00	−0.00	0.03	0.09*	0.01	−0.01	0.01	−0.01	−0.01	0.03	0.01	−0.01
	(0.00)	(0.01)	(0.02)	(0.05)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
inner movement, within	0.05*	0.04	0.11	−0.18	0.00	0.01	0.04	−0.03	0.19***	−0.42***	−0.00	0.01
	(0.03)	(0.07)	(0.11)	(0.26)	(0.03)	(0.07)	(0.02)	(0.06)	(0.07)	(0.16)	(0.03)	(0.07)
population inflow, within	−0.02	−0.22***	0.09	0.09	−0.03	−0.20***	0.03	−0.18***	0.05	−0.11	−0.01	−0.18**
	(0.03)	(0.07)	(0.10)	(0.22)	(0.04)	(0.07)	(0.02)	(0.07)	(0.06)	(0.14)	(0.04)	(0.07)
population inflow, across	−0.01	−0.03	0.01***	0.01***	−0.01	−0.02	−0.00	−0.02	0.00**	−0.01*	−0.01	−0.01
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
Close contacts							0.23***		0.43***		0.12***	
							(0.01)		(0.01)		(0.02)	
New cases								1.63***		2.17***		0.50***
								(0.07)		(0.04)		(0.09)
N	1132	1132	663	663	469	469	1132	1132	663	663	469	469
Panel B: 5 days lag												
#news, within	0.85***	1.41***	0.55	0.54	1.01***	1.37***	0.51***	1.51***	0.31	2.01***	0.80***	0.57***
	(0.10)	(0.25)	(0.39)	(0.84)	(0.15)	(0.29)	(0.10)	(0.07)	(0.28)	(0.05)	(0.15)	(0.09)
#news^2, within	−0.56***	−0.87***	−0.32	−0.08	−0.69***	−0.86***	−0.35***	0.12	−0.28	−0.56	−0.56***	0.79***
	(0.07)	(0.17)	(0.29)	(0.63)	(0.10)	(0.20)	(0.06)	(0.24)	(0.21)	(0.61)	(0.10)	(0.31)
#news, across	0.01	−0.02	−0.05***	−0.06***	0.01	−0.02	0.01*	−0.01	−0.02***	0.55	0.01	−0.47**
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.16)	(0.01)	(0.45)	(0.01)	(0.21)
inner movement, within	0.04*	−0.01	0.18	−0.20	0.03	−0.01	0.05**	−0.03*	0.27***	0.04***	0.03	−0.02
	(0.02)	(0.06)	(0.13)	(0.28)	(0.03)	(0.06)	(0.02)	(0.01)	(0.09)	(0.01)	(0.03)	(0.01)
population inflow, within	−0.05*	−0.23***	−0.21**	−0.27	−0.04	−0.14**	0.01	−0.08	−0.09	−0.56***	−0.02	−0.03
	(0.03)	(0.06)	(0.10)	(0.21)	(0.03)	(0.07)	(0.02)	(0.06)	(0.07)	(0.20)	(0.03)	(0.06)
population inflow, across	−0.00	−0.03	−0.00	−0.01*	−0.00	−0.05**	0.01	−0.16***	0.00	0.16	0.00	−0.11*
	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)	(0.01)	(0.06)	(0.00)	(0.15)	(0.01)	(0.07)
Close contacts							0.24***	−0.03	0.44***	−0.01	0.15***	−0.04**
							(0.01)	(0.02)	(0.01)	(0.00)	(0.02)	(0.02)
New cases								1.51***		2.01***		0.57***
								(0.07)		(0.05)		(0.09)
N	1105	1105	658	658	447	447	1105	1105	658	658	447	447
Panel C: 7 days lag												
#news, within	0.83***	0.92***	0.84	0.46	1.20***	1.00***	0.59***	−0.26	0.62	−0.98	1.04***	0.24
	(0.11)	(0.26)	(0.60)	(1.15)	(0.17)	(0.33)	(0.11)	(0.25)	(0.47)	(0.90)	(0.17)	(0.34)
#news^2, within	−0.57***	−0.60***	−0.16	0.62	−0.84***	−0.67***	−0.41***	0.21	−0.46	0.90	−0.73***	−0.15
	(0.08)	(0.18)	(0.48)	(0.91)	(0.11)	(0.22)	(0.07)	(0.17)	(0.37)	(0.71)	(0.11)	(0.23)
#news, across	0.02	−0.04	0.56**	0.75	0.01	−0.03	0.03*	−0.07*	0.21	−0.21	0.02	−0.04
	(0.02)	(0.04)	(0.25)	(0.48)	(0.02)	(0.04)	(0.02)	(0.04)	(0.20)	(0.38)	(0.02)	(0.04)
inner movement, within	0.07**	0.12	0.11	−0.49	0.06*	0.10	0.04	0.02	0.34**	−0.69***	0.05	0.06
	(0.03)	(0.07)	(0.17)	(0.33)	(0.04)	(0.07)	(0.03)	(0.07)	(0.14)	(0.26)	(0.04)	(0.07)
population inflow, within	−0.01	−0.32***	−0.00	−0.10	−0.05	−0.21*	0.07	−0.30***	0.04	−0.09	−0.02	−0.18
	(0.05)	(0.12)	(0.12)	(0.22)	(0.06)	(0.12)	(0.05)	(0.12)	(0.09)	(0.17)	(0.06)	(0.11)
population inflow, across	0.04	−0.11	−0.11**	−0.15*	0.02	−0.09	0.07	−0.17*	−0.04	0.04	0.04	−0.11
	(0.05)	(0.11)	(0.05)	(0.09)	(0.05)	(0.09)	(0.04)	(0.10)	(0.04)	(0.07)	(0.05)	(0.09)
Close contacts							0.27***		0.47***		0.17***	
							(0.01)		(0.01)		(0.02)	
New cases								1.42***		1.72***		0.63***
								(0.06)		(0.05)		(0.09)
N	1075	1075	650	650	425	425	1075	1075	650	650	425	425
Province FE	√	√	√	√	√	√	√	√	√	√	√	√
Date FE	√	√	√	√	√	√	√	√	√	√	√	√
Controls	√	√	√	√	√	√	√	√	√	√	√	√

Notes: 1. Standard errors in parentheses; 2. * p<0.1, ** p<0.05, *** p<0.01; 3. T=the full sample, T1=subsample with data before Feb 5, T2=subsample with data after Feb 5; 4. R=New cases, C=Close contacts.



Appendix Figure D1. Plots of the relation between news-times and daily patients in every province