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Research article

Effects of media reporting on mitigating spread of COVID-19 in the early phase of the outbreak

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Abstract: The 2019 novel coronavirus disease (COVID-19) is running rampantly in China and is swiftly spreading to other countries in the world, which causes a great concern on the global public health. The absence of specific therapeutic treatment or effective vaccine against COVID-19 call for other avenues of the prevention and control measures. Media reporting is thought to be effective to curb the spreading of an emergency disease in the early stage. Cross-correlation analysis based on our collected data demonstrated a strong correlation between media data and the infection case data. Thus we proposed a deterministic dynamical model to examine the interaction of the disease progression and the media reports and to investigate the effectiveness of media reporting on mitigating the spread of COVID-19. The basic reproduction number was estimated as 5.3167 through parameterization of the model with the number of cumulative confirmed cases, the number of cumulative deaths and the daily number of media items. Sensitivity analysis suggested that, during the early phase of the COVID-19 outbreak, enhancing the response rate of the media reporting to the severity of COVID-19, and enhancing the response rate of the public awareness to the media reports, both can bring forward the peak time and reduce the peak size of the infection significantly. These findings suggested that besides improving the medical levels, media coverage can be considered as an effective way to mitigate the disease spreading during the initial stage of an outbreak.

Keywords: COVID-19; media reporting; mathematical model; basic reproduction number; sensitivity analysis

1. Introduction

Recently, a novel coronavirus is spreading across China and causes a severe outbreak of viral pneumonia, catching the eyes of the world. In December 2019, cases of pneumonia of unknown etiology (unknown cause) were reported in Wuhan City, Hubei Province of China [1]. It was found that a novel coronavirus was the causative virus on 7 January 2020, which was provisionally named 2019 novel corona virus (2019-nCoV) [2]. Though similar with SARS coronavirus and MERS coronavirus, the novel coronavirus is distinct from them [3]. It causes a severe acute respiratory illness and the range of symptoms includes fever, cough, and dyspnoea, with chest radiographs revealing invasive lesions in both lungs [4].

The viral pneumonia was initially reported only in Wuhan in early January 2020, while with the coming of the Chinese Spring Festival, people were travelling more frequently, infected cases were informed in other provinces of China in the next few days. Though the government has taken actions such as travel restriction of Wuhan in time, the COVID-19 is still spreading rapidly in China. As of 7 February 2020, 31,774 confirmed cases and 27,657 suspected cases of COVID-19 infection have been reported in 31 Chinese provinces or municipalities in mainland China, with 722 deaths and 2050 cured cases, 345,498 in contact tracing, of which 189,600 are in clinical medicine observation [5]. In addition, a number of confirmed COVID-19 infection cases have been reported in other countries, including Thailand, Japan, Republic of Korea, USA, Canada, Vietnam, Singapore, France, Germany, Australia, and so on. On 31 January 2020, WHO announced that the COVID-19 outbreak constitutes a Public Heath Emergency of International Concern (PHEIC). On 7 February 2020, the pneumonia infected by the novel coronavirus was provisionally named as Novel Coronavirus Pneumonia (NCP) [6] and formally named as Corona Virus Disease 2019 (COVID-19) by WHO on 11 February [2]. The rapid spread of COVID-19 poses a great burden on the development of the economy and society, causing a great deal of concern among the public and the authorities.

The limitation of the medical resources, the absence of specific anti-COVID-19 therapeutic treatment and effective vaccine against COVID-19, all make it more difficult to curb the transmission of the pneumonia. Thus it's essential to consider some other avenues of control or interventions. Actually, travel restrictions were implemented in China which effectively reduced mobility of millions, and people are requested to stay at home during the outbreak of COVID-19 to reduce the contact rate with others, which indeed contribute to the prevention and control of the disease. However, in the early phase of the outbreak, few information was revealed and few people were aware of the disease, leading to the continuation of frequent movements and the absence of timely control measures of the public, which results in the more severe situation than it is supposed to be. There are evidences shown that media reports and education have the potential to affect the awareness of the public, thus can modify the community's behaviors during the infectious disease outbreak [7, 8]. We've known that behavior change during infectious disease outbreaks can curb the disease spread in populations [9], then examining whether and how the media reporting and the infection dynamics correlating becomes very important, especially during the COVID-19 outbreak.

In fact, the relationship between the mass media and the disease spread is complex and mutual. On one hand, the media reporting about the COVID-19 may influence the attitude of the public towards the disease and enhance their self-protecting awareness. People informed by the media reports will change their behaviours and take correct precautions such as frequent hand-washing, wearing protective masks, keeping social distances, and even quarantining themselves at home to avoid contacting with and being infected by others. On the other hand, the degree of mass media attention to COVID-19 is determined by the severity of the outbreak. While how the media reports contributes to the prevention and control of the COVID-19 infection, and how media reports affect the peak time and peak value of the outbreak remain unknown. Thus quantifying the effectiveness of the media reports on mitigating the spread of COVID-19 is of crucial importance during the early stage of the outbreak. This falls within the scope of our study.

In this study, we developed a deterministic dynamical model to describe the human-to-human transmission of COVID-19 considering media impact. Disease progression is characterized by the basic $SEIR$ model and media is portrayed by disease statistics (number of daily confirmed cases) and incorporated as a separate compartment in the model. We estimated the key parameters and the basic reproduction number of the proposed model by using the accumulated number of reported confirmed cases, the accumulated number of reported deaths, and the average daily number of media items. A sensitivity analysis was carried out to identify parameters affecting the peak time and peak size of the outbreak most, and to indicate the effectiveness of enhancing the media reporting intensity and awareness of the public.

2. Methods

2.1. Data collection and analysis

We obtained the data of COVID-19 cases in Mainland China from the National Health Commission of the People's Republic of China. The data information includes the reported cumulative number of confirmed cases and reported number of deaths, as shown in Figure 1(a). The number of daily confirmed cases (newly reported) was also shown in Figure 1(b). Though the first case was reported in December 2019, no newly confirmed case was reported until 10 January 2020, and 41 confirmed cases were reported on 10 January 2020. Furthermore, we collected the information of 22 cured cases anonymously, especially their curative hospitalization periods, and calculated the average period from hospitalization to recovery as 7.68 days.

We also collected the daily number of media items on the COVID-19 from seven authoritative or popular websites including cnr.cn (China National Radio), gov.cn (the Central People's Government of the People's Republic of China), chinacdc.cn (Chinese Center for Disease Control and Prevention), xinhuanet.com (Xinhuanet), people.com.cn (People's Daily Online), chinanews.com (China News), and news.sina.com.cn (Sina) from 10 January 2020, by using the key word 'novel coronavirus' included in the title or the full text, as shown in Figure 1(c). In addition, we obtained the daily number of IP addresses that visit each website, as shown in Figure 1(d).

Then we got the average daily number of media items by defining an index 'hotness' as the weighting coefficients to average the number of media items collected in the seven websites, as shown in Figure 1(b). Denote the daily number of media items collected in each website by x_i, and the daily number of IP addresses visiting each website as p_i, where $i = 1, 2, 3, 4, 5, 6, 7$ denote cnr.cn, gov.cn, chinacdc.cn, xinhuanet.com, people.com.cn, chinanews.com, news.sina.com.cn, respectively. Then the average daily number of media items x is

$$x = h_i x_i,$$

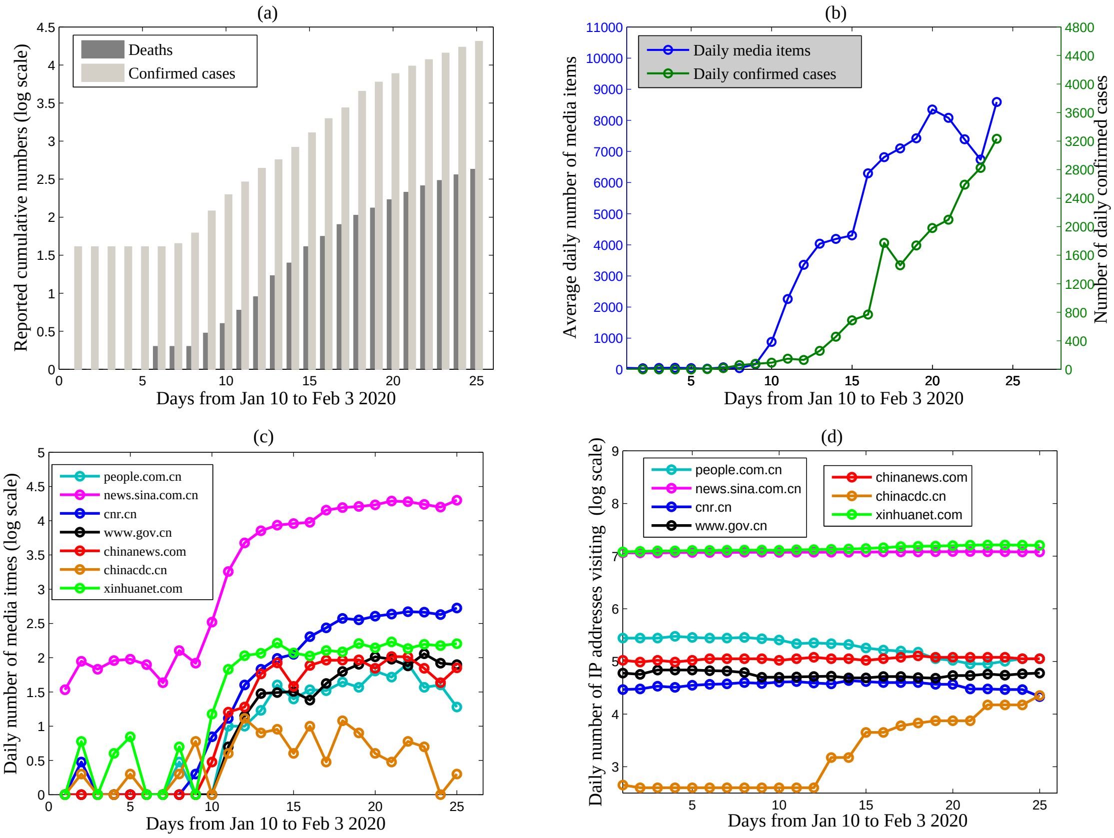

Figure 1. (a) Number of cumulative confirmed cases and number of cumulative number deaths from January 10 to February 3; (b) Number of daily confirmed cases and the average daily number of media items; (c) and (d) Number of daily media items and the number of IP addresses visiting people.com.cn, news.sina.com.cn, cnr.cn, gov.cn, chinanews.com, chinacdc.cn, xinhuanet.com, respectively.

where $h_i = \frac{p_i}{\Sigma_{i=1}^{7} p_i}$ represents the index hotness of each website.

We can observe directly from Figure 1(b) that the average daily number of media items and the number of daily confirmed cases are in a strong relationship. Then denote the number of daily confirmed cases of COVID-19 by y, we analyzed the association between the average daily number of media items (x) and the number of daily confirmed cases (y) from January 10 to 31, 2020 at specific lags, by conducting the cross-correlation analysis [10, 11].

2.2. *The model*

We proposed a dynamic compartmental model (2.1) incorporating the awareness programs as a separate compartment to describe the transmission of COVID-19 affected by the media reports, based on the disease progression, the intervention measures, and the interconnected relationship between media reports and the disease progression. In this model, the population is divided into seven compartments, including susceptible (S), quarantined susceptible (S_q), infectious without symptoms (or exposed E), quarantined exposed (E_q), infectious with symptoms (or infected I), hospitalized (H)

and recovered (R), M represents the cumulative density of awareness programs driven by the media reports.

Here we assumed that contact tracing is implemented and a proportion of q of individuals exposed to the virus is quarantined and the other proportion of $1 - q$ is missed from the contact tracing. The quarantined individuals and the individuals missed from the contact tracing have a probability β of effectively infected and then move to the (quarantined) exposed compartment (E_q or E), while the others, with a probability of $1-\beta$, would stay in the (quarantined) susceptible compartment (S_q or S). We also assume that the quarantined exposed individuals (E_q) would be hospitalized once the detected result is positive. c is the contact rate, β is the transmission probability, θ is the relative transmission probability of exposed individuals to infected individuals, $1/\sigma$ is the incubation period and α is the disease-induced death rate, δ_I and δ_q are the hospitalized rates for I and E_q, respectively, γ_I and γ_H are the cured rates for infected and hospitalized individuals, respectively, λ is the releasing rate of quarantined individuals. For the parameters related with the media reports, e^{-pM} is the media function which means that the contact rate is reduced due to awareness driven by media reports, λ_M represents the initiative quarantined rate induced by awareness driven by media reports, η is the response intensity of awareness programs on the number of newly confirmed cases, μ_M is the waning rate of awareness programs due to ineffectiveness, social problems, etc. See more detailed definitions of variables and parameters listed in Table 1.

$$\begin{cases} S' = -(ce^{-pM}\beta + ce^{-pM}q(1-\beta))S(I+\theta E) - \lambda_M SM + \lambda S_q, \\ E' = ce^{-pM}\beta(1-q)S(I+\theta E) - \sigma E - \lambda_M EM, \\ I' = \sigma E - (\alpha + \delta_I + \gamma_I)I, \\ S_q' = ce^{-pM}(1-\beta)qS(I+\theta E) + \lambda_M SM - \lambda S_q, \\ E_q' = ce^{-pM}\beta qS(I+\theta E) + \lambda_M EM - \delta_q E_q, \\ H' = \delta_I I + \delta_q E_q - \gamma_H H - \alpha H, \\ R' = \gamma_I I + \gamma_H H, \\ M' = \eta(\delta_I I + \delta_q E_q) - \mu_M M. \end{cases} \tag{2.1}$$

2.3. Simulation

We used data extracted from the National Health Commission of the People's Republic of China from 10 January to 31 January, 2020, to study the effects of media reports. Parameter values for model (2.1) were informed by the literature or further estimated by data fitting using the Least Square Method.

In the initial stage of the epidemic, the COVID-19 was mainly transmitted in Wuhan, where the population of inhabitants was about 11,081,000 [12], thus we set $S(0) = 11,081,000$ [13]. The quarantined individuals are required to be isolated 14 days, thus $\lambda = 1/14$ [13]. The incubation period is 3–7 days [14], here we choose $\sigma = 1/5$. As illustrated in the previous section, the average period from hospitalization to recovery is 7.68 days, thus we choose $\gamma = 1/7.68$.

To identify the key parameters that influence the disease infection dynamics, we examined the dependence of the peak time and peak size of the total number of infected and hospitalized individuals ($I(t)+H(t)$) on corresponding model parameters, by using Latin Hypercube Sampling (LHS) and partial rank correlation coefficients (PRCCs).

3. Results

3.1. Cross-correlation coefficients

Sample cross-correlation coefficients are shown in Figure 2, from which we can see that x is positive correlated to y at lags ranging from −5 to 3 and the local maximal cross-correlation coefficient occurs at lag = 0. The statistically significant cross-correlation between x and y indicates that the average daily number of media items and the number of daily confirmed cases are strongly interconnected. This confirms the comparatively reasonable modelling of the media compartment in model (2.1).

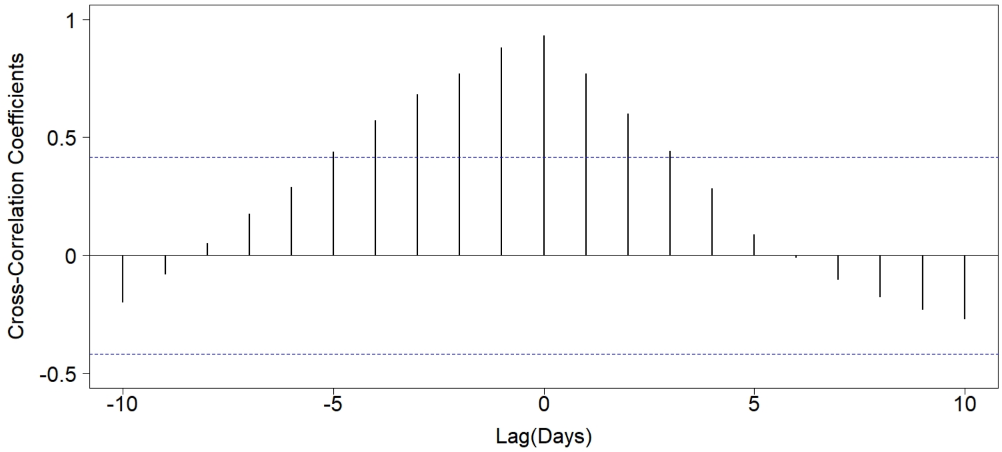

Figure 2. Cross-correlation coefficients between the average daily number of media items and the number of daily confirmed cases of COVID-19 in China from 10 January to 31 January, 2020.

3.2. Parameter estimation

As we all know, the transmissibility of a virus at the initial stage of an epidemic is measured by the basic reproduction number R_0, which measures the average number of new infections generated by one infected individual in the population during the average infection period. By using the next generation matrix, we got the basic reproduction number for system (2.1) as

$$R_0 = \left(\frac{c\beta(1-q)}{\delta_I + \alpha + \gamma_I} + \frac{c\beta(1-q)\theta}{\sigma}\right)S_0.$$

Then by fitting the model to the data of accumulated number of confirmed cases, accumulated number of deaths, and average daily number of media items from January 10 to January 31, 2020, the basic reproduction number is estimated as $R_0 = 5.3167$, which is lower than the result in [13, 15] while greater than that in [18, 19], and the parameter estimations are shown in Table 1. The good fitness is shown in Figure 3, in which the black markers are the data from January 10–31, the red curves are the fitting curves, and the blue markers are the data from February 1–3 to verify our estimation and prediction of the trend of COVID-19 infection and the media reports.

Table 1. Estimated initial values of variables and parameters for system (2.1).

Variables	Description	initial value	Resource
S	Susceptible population	11081000	[12, 13]
E	Exposed population	118.552	LS
I	Infected population with symptomatic	20	LS
S_q	Quarantined susceptible population	739	[16]
E_q	isolated exposed population	1	LS
H	Hospitalized population	1	[13]
R	Recovered population	2	[16]
M	Media items	16.3	Data
Parameters	Description	Value	Resource
c	Contact rate (per person per day)	10.582	LS
β	Probability of transmission from I to S per contact	2.010×10^{-8}	LS
θ	Relative transmission probability of E compared with I	1.000×10^{-6}	LS
q	Quarantined proportion of latent individuals	1.000×10^{-8}	LS
p	Weight of media effect on contact rate sensitive to media items	9.003×10^{-5}	LS
λ_M	Quarantined rate of individuals induced by media reporting (per day)	5.471×10^{-5}	LS
λ	Releasing rate of quarantined individuals (per day)	1/14	[13]
σ	Progression rate of exposed individuals to infectives (per day)	1/5	[14, 17, 18]
α	Disease-induced death rate (per day)	0.003	LS
δ_I	Progression rate of infectives to hospitalized individuals (per day)	0.110	LS
γ_I	Recovery rate of infected individuals (per day)	0.330	[13]
δ_q	Progression rate of quarantined exposed to hospitalized class (per day)	0.102	LS
γ_H	Recovery rate of hospitalized individuals (per day)	0.130	Data
η	Media reporting rate of number of newly hospital notifications (per person)	2.951	LS
μ_M	Media waning rate (per day)	0.735	LS

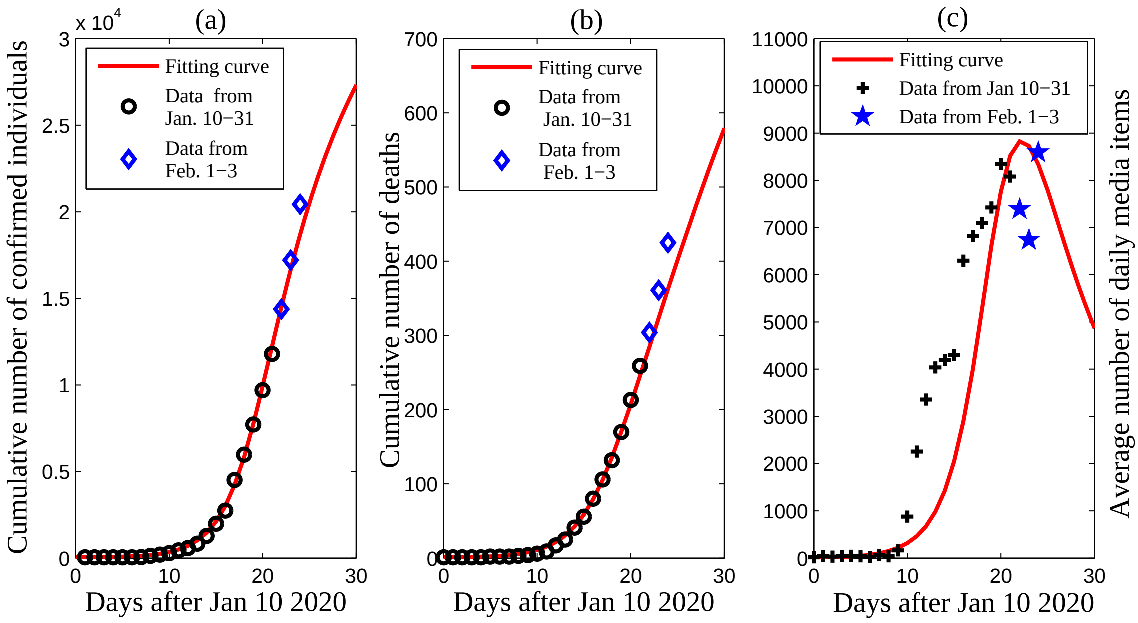

Figure 3. Data fitting for the data from January 10 to 31, 2020. The markers represent (a) the cumulative number of confirmed cases, (b) the cumulative number of deaths, (c) the average daily number of media items, from January 10 to 31 (black markers), and from February 1 to 3 (blue markers), respectively. The red curves are the best fitting curves of model (2.1) to these data.

3.3. Uncertainty and sensitivity analysis

It follows from Figure 4 that the contact rate c, the transmission probability β, the transition rate from exposed to symptomatic σ (or the incubation period $1/\sigma$) are the most sensitive parameters to the peak time and peak size. In particular, Figure 4 shows that reducing the contact rate c and decreasing the transmission probability β could delay the peak time and lower the peak size of the total number of infected and hospitalized individuals, shortening the incubation period $1/\sigma$ and the hospitalized period $1/\gamma_H$, could bring forward the peak time significantly, increasing the hospitalized rate of infected individuals δ_I can greatly reduce the peak size of the total number of infected and hospitalized individuals. Despite these significantly sensitive parameters associated with the disease transmissibility, the parameters related to the media reports can also significantly affect the results. To be more detailed, enhancing the response intensity of awareness programs on the number of newly confirmed cases η, or improving the awareness and quarantined rate of individuals to media reports λ_M could not only bring forward the peak time but also reduce the peak size of the total number of infected and hospitalized individuals significantly. Since we are focusing on the media impact on the transmission of COVID-19, we plotted the contour plots to examine the dependence of the peak time and peak size of the total number of infected and hospitalized individuals on the media reporting rate η and the media waning rate μ_M (Figure 5), and on the weight of the media impact on the contact rate p and the media-induced quarantined rate λ_M (Figure 6). The results indicated that, with increasing of η, λ_M, p, and decreasing of μ_M, the peak time is brought forward and the peak size is lowered, illustrating that the media reports during the early stage of the disease outbreak would reduce the severity of the epidemic.

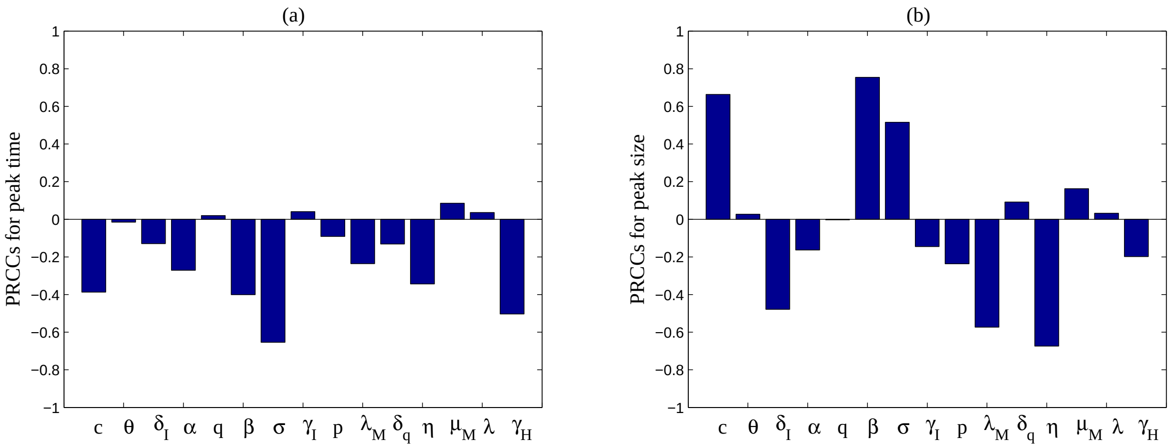

Figure 4. Sensitivity analysis of (a) the peak time and (b) peak size of the total number of infected and hospitalized individuals with respect to parameters $c, \theta, \delta_I, \alpha, q, \beta, \sigma, \gamma_I, p, \lambda_M, \delta_q, \eta, \mu_M, \lambda, \gamma_H$, respectively. The Latin Hypercube Sampling was done with 5000 bins.

To further investigate the explicit effectiveness of media reports on the COVID-19 outbreak, we plotted the total number of infected and hospitalized individuals $(I(t) + H(t))$ with different values of the media reporting rate η (Figure 7(a)), the media waning rate μ_M (Figure 7(b)), the weight of the media impact on the contact rate p (Figure 7(c)), the media-induced quarantined rate λ_M

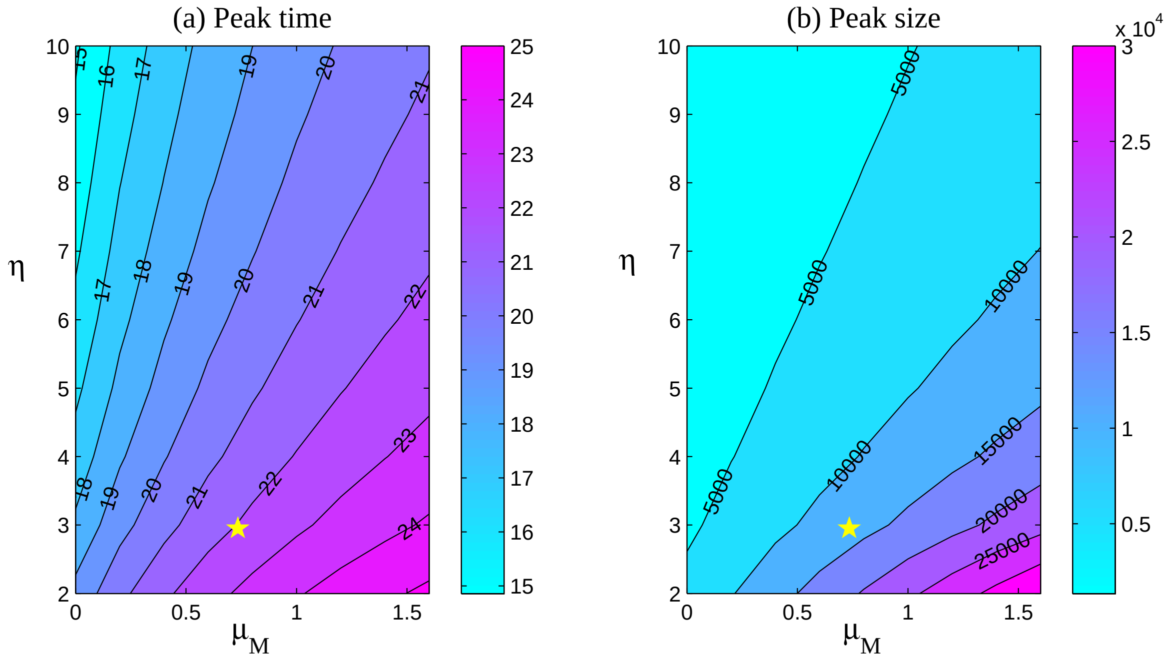

Figure 5. Contour plots of the peak time and peak size of the total number of infected and hospitalized individuals with respect to μ_M and η. The yellow star represents the position of (μ_M, η) we have estimated by using the data to fit model (2.1).

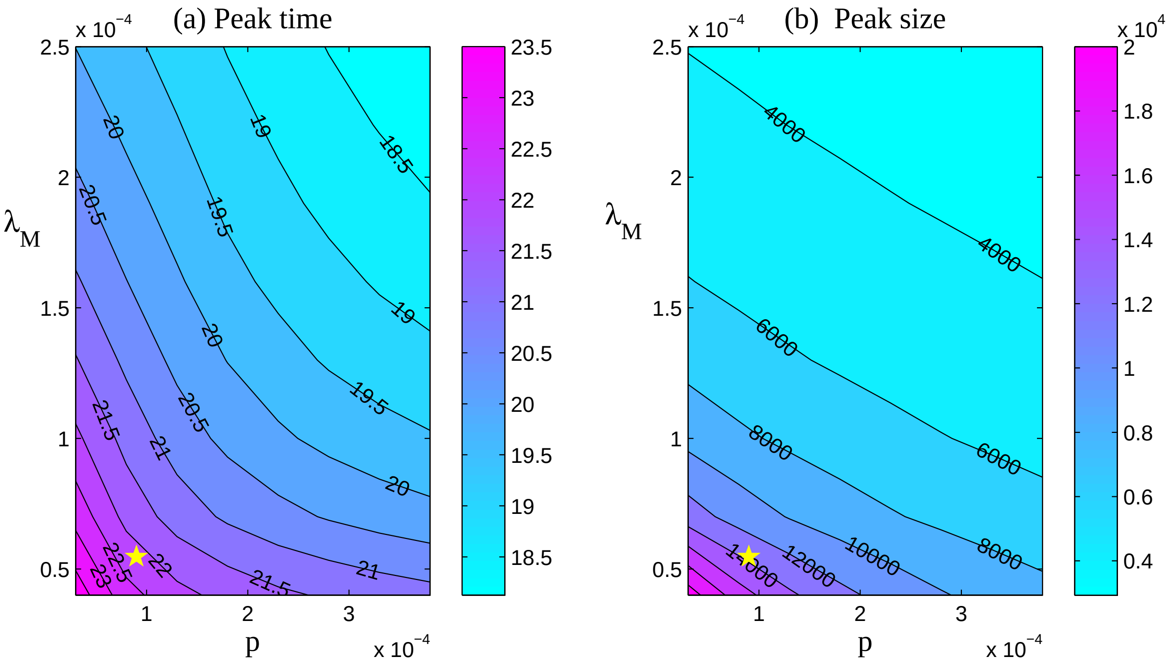

Figure 6. Contour plots of the peak time and peak size of the total number of infected and hospitalized individuals with respect to p and λ_M. The yellow star represents the position of (p, λ_M) we have estimated by using the data to fit model (2.1).

(Figure 7(d)), respectively, with all other parameters fixed. In particular, the results showed that enhancing the response rate of the media reports to the newly confirmed cases, i.e., increasing η by 5 times from its baseline value would lead to 4.35 days earlier of the peak time (from 22.08 days to 17.73 days after January 10) and reduce the peak size from 13,063 to 2630 (decreased by 79.87%), as shown in Figure 7(a). Reducing the media waning rate μ_M to $0.1\mu_M$ could bring forward the peak time to 18.84 days after January 10 (3.24 days earlier) and reduce the peak size to 5112 (reduced by 60.87%), as can be seen in Figure 7(b). Meanwhile, enhancing the response rate of the public to the media reports, for example, increasing the media induced quarantined rate λ_M by 10 times from its baseline value would bring forward the peak time by 4.28 days (from 22.08 days to 17.8 days after January 10), and reduce the peak size from 13,063 to 1787 (reduced by 86.31%), as shown in Figure 7(d), or, increasing p to $8p$ could bring forward the peak time to 20.06 days after January 10 (about 2 days earlier) and reduce the peak size to 5172 (reduced by 60.41%), as shown in Figure 7(c). These sensitivity analysis showed that enhancing the response rate of the media reporting to the severity of COVID-19, and enhancing the response rate of the public awareness to the media reports, both can bring forward the peak time and reduce the peak size of the infection significantly, during the early phase of the COVID-19 outbreak.

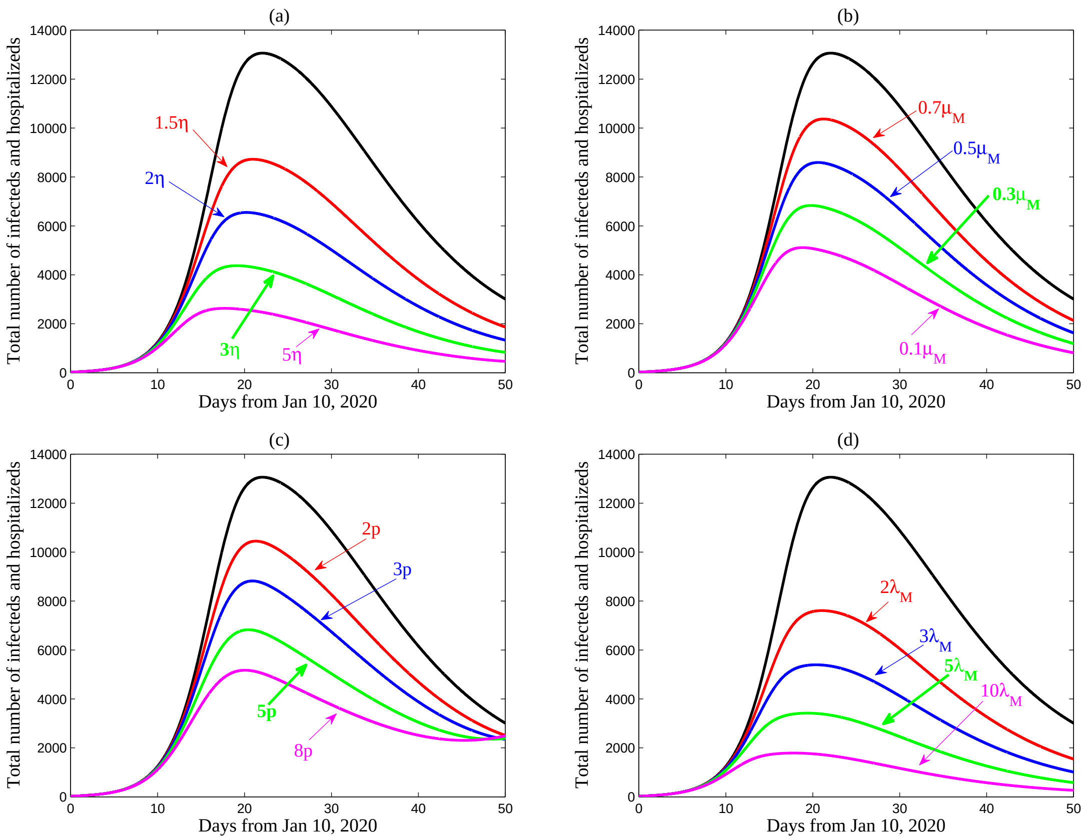

Figure 7. Variation of total number of infected and hospitalized individuals with different values of (a)η, (b) μ_M, (c) p, (d)λ_M.

4. Discussion

Since the first pneumonic case of novel coronavirus was reported in Wuhan City, Hubei Province, China on 12 December 2019, an outbreak of novel coronavirus (COVID-19) has swiftly spread across 34 Chinese provinces or municipalities in China and a number of foreign countries. It is well knowledged that exposed infection and person-to-person transmission appear possible [20] and Chinese Government has implemented timely control measures to mitigate the spread of the virus. However, in the current situation, medical resources are in critical needed and antiviral drugs or vaccine are still in development, control measures mainly include the various social and personal non-pharmaceutical interventions, including media education. The media educated public then take various precautions, for instance, wearing face masks, keeping social distance and frequent hand-washing, to reduce the chance of being infected. This has indeed influenced the pattern of disease transmission and lowered the rate of contact. From the viewpoint of the public health control, it is important to quantify how the number of daily media items provide new insights into the progression of COVID-19 and consequently help curb COVID-19 spreading. To address such an important issue, we have proposed a deterministic dynamic model based on the transmission pattern and clinical feature of COVID-19 in our work. The mass media is represented as a state variable, and a negative exponential function is introduced to the transmission term to describe the effect of media on the contact rate, and also, a media-induced quarantine is considered.

To get a comprehensive understanding of the media effects during the early phase of COVID-19 outbreak, we have collected the data including the daily number of media items and the number of IP addresses visiting seven popular and authoritative websites: cnr.cn, gov.cn, chinacdc.cn, xinhuanet.com, people.com.cn, chinanews.com, and news.sina.com.cn (Figure 1(c) and 1(d)). By introducing the index 'hotness' of a website according to the number of visiting IP addresses, we have calculated the average daily number of media items (Figure 1(b)), from which we can intuitionisticly see that the number of daily confirmed cases and the average daily number of media items are in a strong relationship. The cross-correlation analysis verified that (Figure 2) and confirmed the comparatively reasonable modelling of the media compartment in model (2.1). By using the data of cumulative number of confirmed cases, cumulative number of deaths and average daily number of media items, the unknown parameters were estimated with Least Square Method. Note that the basic reproduction number was calculated as 5.3167, greater than WHO estimates (1.4–2.5) and the results in [18, 19, 21], but lower than the results in [13, 15]. A review research about the basic reproduction number has shown that the WHO may underestimate the R_0, which is lower than almost all studies in the early stage [22]. Meanwhile, the estimation of R_0 depends on the methods used, the assumptions and the length of time intervals of data. In particular, in the early phase of the outbreak, insufficient data may cause the estimation biased. Thus further work should be conducted based on more explicit data.

We carried out the sensitivity analysis of the peak time and peak size of the total number of infected and hospitalized individuals with respect to the model parameters. The result identified three key parameters: the contact rate c, the transmission probability β, and the progression rate from exposed to symptomatic σ, play an important role in both the peak time and the peak size. This suggested the vital role of quarantine and isolation in the early phase for this deadly infectious disease, besides its high infectivity and long incubation period. The finding also demonstrated that improving the detection rate and hospitalized rate δ_I, or improving the discharged rate γ_H can help reduce the severity of the outbreak significantly, or bring forward the peak time.

In addition, it is worth emphasizing that besides the above disease control parameters, media reports can also greatly affect the peak time and peak size. The peak size can be reduced greatly and the peak time can be brought forward by enhancing the response intensity of mass media to the newly confirmed cases η, weakening the waning rate of the awareness programs induced by media reports μ_M, increasing media-induced quarantined rate λ_M or raising the weight of public awareness to the media reports p. These results indicated that both enhancing the response rate of the media reporting to the severity of the outbreak, and enhancing the response rate of the public awareness to the media reports, can bring forward the peak time and reduce the peak size of the infection significantly, illustrating the important role of media reports on mitigating the spread of COVID-19 during the early phase of the outbreak.

We have to point out that the disease induced death rate ($\alpha = 0.003$) in our model represents the proportion of deaths to the infecteds per day, which is different from the case fatality rate (the ratio of accumulative deaths to the accumulative confirmed cases). And the disease induced deaths appeared not only in the confirmed cases (i.e., H class in our model) but also in the infecteds (i.e., I class in our model, people had been infected but not been confirmed). In more detail, the infection-fatality rate for infecteds is $\alpha/(\alpha + \delta_I + \gamma_I) = 0.0068$, and the hospitalization-fatality-rate for those confirmed cases is $\alpha/(\alpha + \gamma_H) = 0.0226$, which is in a reasonable range of the fatality rate derived by the Novel Coronavirus Pneumonia Emergency Response Epidemiology Team [23]. The team have found that a total of 1023 deaths have occurred among 44,672 confirmed cases for an overall case fatality of 2.3% by studing 72,314 patient records. Another point we should note is that there were indeed more than 41 cases before Jan 10, 2020 [23]. The long detection period, the lack of public awareness of the virus and the untimely official reporting, may cause the reported confirmed cases lower than the true numbers at the beginning. Here we used the data collected from the National Health Commission of the People's Republic of China without retrospective studying (since in the early stage, data was insufficient). However, in our model fitting, the estimated total number of infectious persons (E+I) was more than 100 on Jan 10, 2020, which also indicated that the cases were more than that was reported. Furthermore, the testing capacity was low in the initial phase of the outbreak, and the detection technology was developing gradually. For example, according to Wuhan Municipal Health Commission [24], the samples could only be tested in the designated organization in Beijing which would take about 5 days to get the results before 16th January 2020, and about 200 samples could be tested in Hubei Provincial CDC every day from 16th to 22nd January. After 22nd January, about 2000 samples could be tested in Wuhan every day, and the capacity was improving gradually with more designated testing organizations. Thus it is more reasonable to incorporate a time varying detection rate in the model, which is a course for our further work.

5. Conclusions

During the raging of COVID-19 in China and other countries, mass media plays an important role in curbing the transmission. The average daily number of media reporting, calculated in terms of the index 'hotness', the daily number of media items and daily number of IP visiting addresses, exhibited a strong correlation to the daily number of newly confirmed cases. Cross-correlation analysis further confirmed the interconnection between the case data and media data. In this work, we formulated a dynamic compartment model by setting media programs as a separate state variable to assess the impact of media on disease control. The good fitness of our targeted model to the data confirmed the model advising. The basic reproduction number was estimated as 5.3167, which demonstrated the highly transmissibility of COVID-19. Sensitivity analysis identified three key parameters: the contact rate, the transmission probability, and the progression rate from exposed to symptomatic, all of which had the greatest impact on peak time and peak size. It should be emphasized that the peak time can be brought forward and the peak size can be diminished significantly, if either the response rate of the media reporting to the severity of COVID-19 or the response rate of the public awareness to the media reports is improved. With developing of the testing technology, supply of the detection reagents and more information disclosure, the case detection, diagnosing and official reporting rate would be enhanced, the model should be adjusted and retrospective studies can be done. While in the initial stage of the outbreak, with insufficient resources and data, media coverage can be considered as an effective way to curb the spread of COVID-19.

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Conflict of interest

The authors declare no conflict of interest.

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