Supplementary Appendix:

Lockdown may partially halt the spread of 2019 novel coronavirus in Hubei province, China

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This is a supplementary document describing mathematical modelling details presented in the main text and parameters estimation.

1. Model formulation

We proposed a dynamic compartmental model to describe the transmission of 2019-nCov in China. The population was divided into five compartments: susceptible individuals (*S*), asymptomatic (but infectious) individuals during the incubation period (*E*), infectious individuals with symptoms (*I*), isolated individuals with treatment (*T*), and recovered individuals (*R*). The total population size was denoted as *N*, (*N*=*S*+*E*+*I*+*T*+*R*). Susceptible individuals became infected by being in contact with infectious individuals with or without symptoms and entered the latent compartment at the rate $\beta_I(t)SI/N + \beta_E(t)SE/N$, where

$$\beta_I(t) = 1-((1-\beta)^{m*(1-p(t))}) * ((1-(1-\theta)*\beta)^{m*p(t)}),$$
$$\beta_E(t) = 1-((1-\varepsilon*\beta)^{m*(1-p(t))}) * ((1-(1-\theta)*\varepsilon*\beta)^{m*p(t)}),$$

of which β denoted the probability of transmission per contact with the infectious individuals with symptoms and we assumed this probability was lower ($\varepsilon\beta$, here $0 \le \varepsilon \le 1$) when contacted with the latent individuals. m denoted the average number of daily person-to-person contacts. $p(t)$ denoted the usage rate of the mask and we assumed that it increased as the epidemic become increasingly severe. θ denoted the effectiveness of mask to prevent infection. Individuals in the incubation period progressed to the infectious compartment at a rate k, and infectious individuals were diagnosed and isolated at the rate α. We assumed strict isolation that isolated individuals could not further infect others. Isolated individuals recovered at the rate γor died due to the disease at the rate μ. The model was described by the following system of ordinary differential equations:

$$\begin{cases} \frac{dS}{dt} = -\beta_I(t)\frac{SI}{N} - \beta_E(t)\frac{SE}{N}, \\ \frac{dE}{dt} = \beta_I(t)\frac{SI}{N} + \beta_E(t)\frac{SE}{N} - kE, \\ \frac{dI}{dt} = kE - \alpha I, \\ \frac{dJ}{dt} = \alpha I - (\gamma+\mu)J, \\ \frac{dR}{dt} = \gamma J. \end{cases} \quad (1)$$

The cumulative number of infected cases *C* and deaths *D* (*C* and *D* were not epidemiological states) were governed by the equations

$$\frac{dC}{dt} = kE, \frac{dD}{dt} = \mu J. \quad (2)$$

The basic (R_0) and effective ($R_e(t)$) reproduction numbers were defined similarly as in [1,2], they were $R_0 = \frac{\beta_I(0)}{\alpha} + \frac{\beta_E(0)}{k} = \frac{1-(1-\beta)^m}{\alpha} + \frac{1-(1-\varepsilon*\beta)^m}{k}$ and $R_e(t) = (\frac{\beta_I(t)}{\alpha} + \frac{\beta_E(t)}{k})\frac{S}{N}$.

2. Data sources and parameter estimation

We collected the data on the number of cumulative confirmed cases and deaths from 15th January 2020 (as the starting date for the epidemic model, i.e., t=0) to 30th January 2020 from the Wuhan Municipal Health Commission [3] and the National Health Commission of the People's Republic of China [4] (Table S1). The mean incubation time for 2019-nCov was five days (1/k=5) [5] and the mean 'time from symptoms onset to quarantine' was six days (1/α =7) [6]. The mean 'time from quarantine to recovery' is approximately five days (1/γ =5) [7,8]. We assume the number of person-to-person contacts m per day among its residents has reduced from ten [9] to four, which is about the size of a family in China after the lockdown initiated on 23rd January 2020 (Figure S1). The percentage of facial mask usage $p(t)$ in public space has also drastically increased to almost 100% in Hubei province during the lockdown, so we assume a logistic growth for this percentage, i.e., $p(t) = 1/1 + \exp(-k_0(t - t_1))$. Here we assume $k_0 = 0.5$ and vary it from 0.3 to 0.7 in the sensitivity analysis and $t_1 = 8$ (23rd January minus 15th January) as shown in Figure S2. The effectiveness of mask to prevent infection θ is chosen as 0.9 (0.8-0.95) [10]. The total population size in Hubei Province was 59,170,000 based on China Population and Employment Statistics Yearbook in 2019. The initial values of the disease states were given as I(0)=41, J(0)=0, R(0)=0, N(0)= 59,170,000 and left E(0) as an estimated parameter.

We calibrated the model (Eq. (2)) to the cases and deaths data from 15th January 2020 to 22th January 2020 by using nonlinear least-squares method and thus we obtained the point estimate of the following parameters: the initial value of latent individuals E(0), the probability of transmission per contact with the infectious individuals with symptoms β, the relative transmissibility of latent individuals compared with the infectious individuals with symptoms ε, and the disease-induced death rate μ. Then we used these estimated values as prior information in MCMC methods with a Metropolis-Hastings (M-H) algorithm [11] implemented by *Matlab* 2019. The algorithm was run for 10,000 iterations with a burn-in (some iterations at the beginning of an MCMC run were discarded) of 5000 iterations, and we used the rest 5000 iterations to derive the mean value and listed 95% CI of these parameters in Table S2. We used data from 23rd January 2020 to 30th January 2020 as validation.

Based on these estimated parameter values, we used the model (Eq. (1)-(2)) to forecast the epidemic trend, including cumulative cases and deaths, the number of infectious individuals with and without symptoms (Figure 1 in the main text), and effective reproduction number (Figure S3) over six months since the epidemic initiation. We also explored how the 7-days delay, 14-days delay, 'no lockdown' would affect the epidemic trend compared with the status quo (lockdown on 23 Jan 2020).

Table S1. Reported cumulative confirmed cases and deaths data in Hubei Province, China [3,4].

Date	Cases	Deaths
2020-1-15	41	2
2020-1-16	45	2
2020-1-17	62	2
2020-1-18	121	3
2020-1-19	198	4
2020-1-20	270	6
2020-1-21	375	9
2020-1-22	444	17
2020-1-23	549	24
2020-1-24	729	39
2020-1-25	1052	52
2020-1-26	1423	76
2020-1-27	2714	100
2020-1-28	3554	125
2020-1-29	4586	162
2020-1-30	5806	204

Table S2. The value of parameters based on references or assumptions, or being estimated using Markov Chain Monte Carlo (MCMC) methods [11].

Parameter denotation	Parameter description	Range or 95%CI from MCMC	Sources
$1/k$	The mean incubation time	5 (3-7)	[5]
$1/\alpha$	The mean time from symptoms onset to isolation	7 (4-8)	[6]
$1/\gamma$	The mean time from isolation to recovery	5 (4-6)	[7,8]
m	The average number of daily contacts before lockdown	10 (1-50)	[9]
	The average number of daily contacts after lockdown	4	Assumed
E(0)	The initial value of latent individuals	187.3172 (186.4671-188.1672)	MCMC
β	The probability of transmission per contact with infectious individuals with symptoms	0.1018 (0.0999-0.1036)	MCMC
ε	The relative transmissibility of latent individuals compared with infectious individuals with symptoms	0.4522 (0.4219-0.4824)	MCMC
$p(t)$	The usage rate of facial mask	$\frac{1}{1+\exp(-0.5(t-8))}$	See text
θ	The effectiveness of mask to prevent infection	0.9 (0.8-0.95)	[10]
μ	Disease-induced death rate	0.0261 (0.0258-0.0264)	MCMC

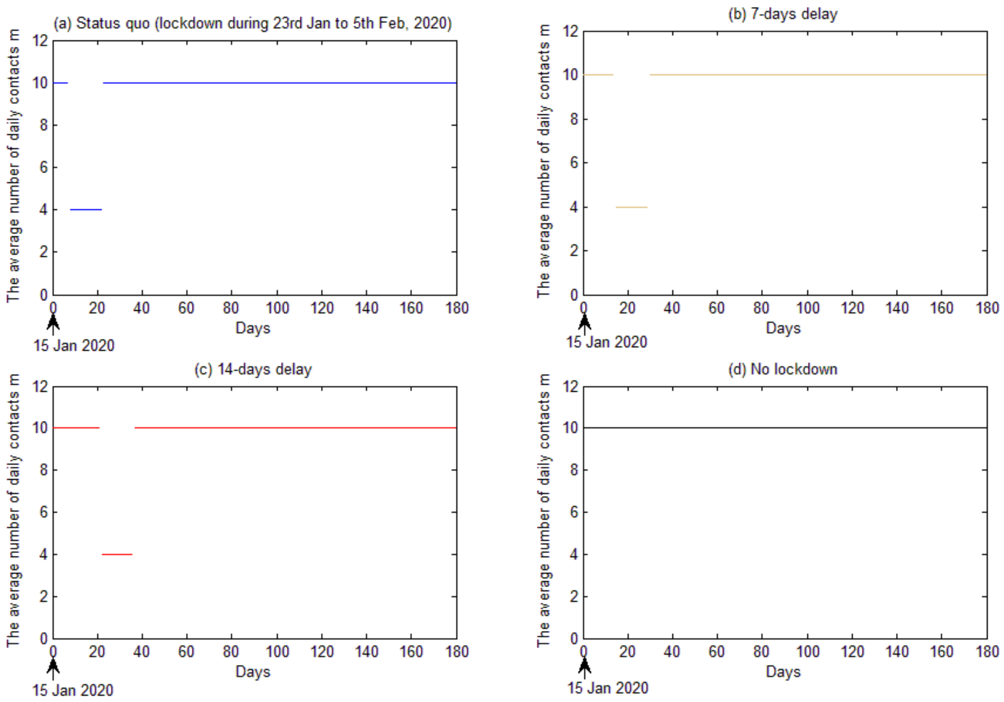

Figure S1. The average number of daily contacts *m* over time for four scenarios: (a) status quo (lockdown during 23rd Jan to 5th Feb 2020); (b) 7-days delay; (c) 14-days delay; and (d) no lockdown.

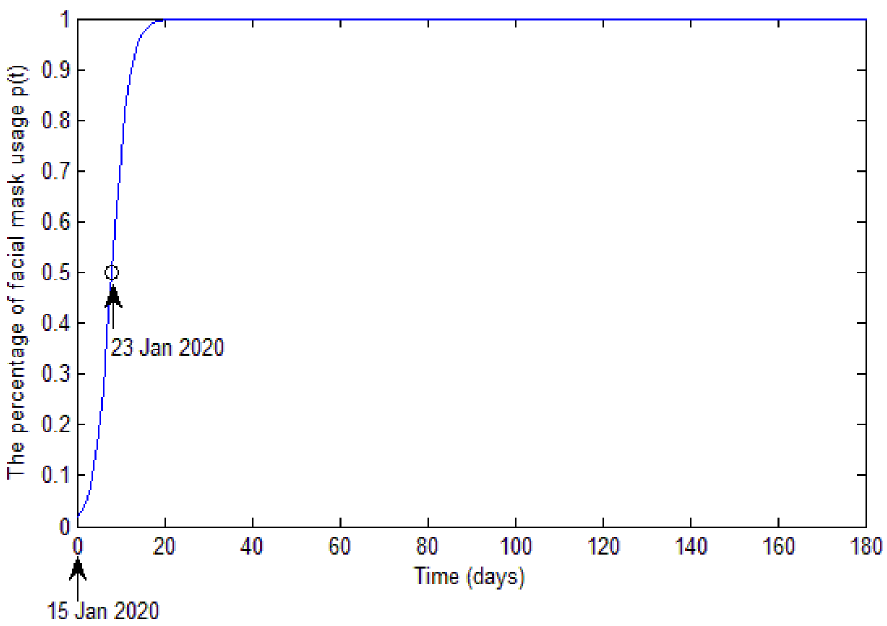

Figure S2. The percentage of facial mask usage $p(t) = \frac{1}{1+\exp(-0.5(t-8))}$ over time.

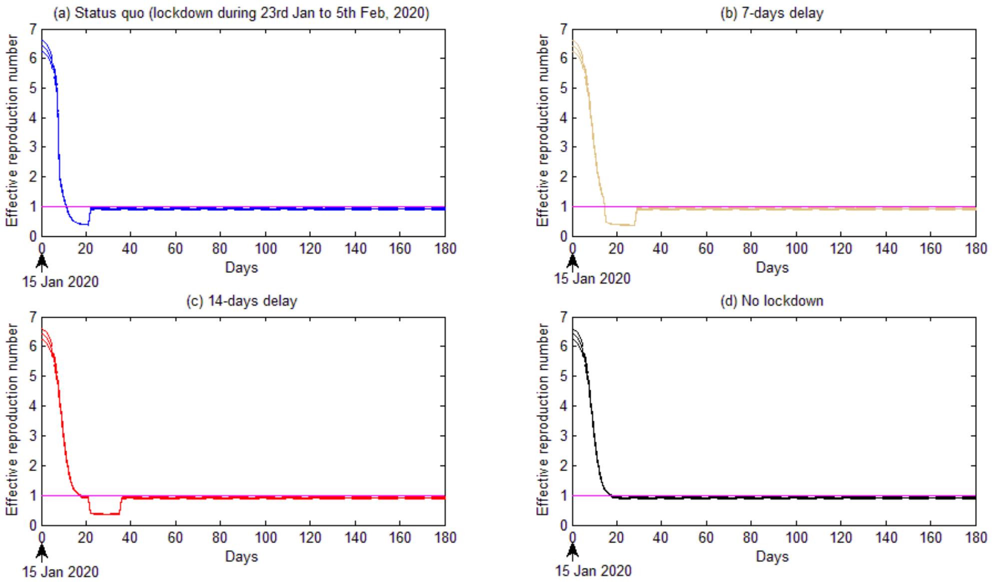

Figure S3. Effective reproduction number over time for four scenarios: (a) status quo (lockdown during 23rd Jan to 5th Feb 2020); (b) 7-days delay; (c) 14-days delay; and (d) no lockdown.

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