Supplementary Material

Calculation of R_0 in the model

Mathematical properties: For a non-negative stochastic variable a that is distributed according to a probability density function $g(a)$, the moment generating function is defined as $M_{g(a)}(z) = \int_{a=0}^{\infty} e^{za}\ g(a)\mathrm{d}a$. When the integral is finite, there is a unique relation between the probability density function and its moment generating function. The moment generating functions have several mathematical properties.

In the paper [1] have exploited the following properties: When the random variable a, distributed according to $g(a)$, can be thought of as the sum of two independent random variables $a1$ and $a2$, such that $a = a1 + a2$, with $a1$ and $a2$ distributed according to $f(a1)$ and $h(a2)$, the moment generating function for the random variable a can be composed of the moment generating function for $a1$ and $a2$: $M_{g(a)}(z) = M_{f(a)}(z) \times M_{h(a)}(z)$.

The moment generating function for the generation interval can be composed from moment generating functions for the durations of successive stages in the infection cycle. We introduce two distributions for the successive stages: $f(a)$ gives the duration from infection to becoming infectious, and $h(a)$ gives the duration from becoming infectious to infection. The moment generating function for the composite generation interval is then given by:

$$M_{g(a)} = M_{f(a)} \times M_{h(a)}$$

In our model, the incubation period obeys the normal distribution, and the infectious period obeys the exponential distribution.

$$R = \frac{1}{M(z)} = \frac{1}{M_{f(a)}(z)} \cdot \frac{1}{M_{h(a)}(z)}$$

$\frac{1}{M_{f(a)}(z)} = e^{\mu r - \frac{1}{2}\sigma^2 r^2}$ [f(a) incubation period obeys the normal distribution]

$\frac{1}{M_{h(a)}(z)} = (1 + \frac{r}{b})$ [h(a) infectious period obeys the exponential distribution]

Therefore, $R = e^{\mu r - \frac{1}{2}\sigma^2 r^2} \cdot (1 + \frac{r}{b})$.

Network Parameter Settings

Number of nodes per network layer: The proportion of community workers is derived from the literature [2]. This paper investigated the contact between people in Chinese communities and gives a detailed distribution. We consider nodes with degrees greater than 30 to be community workers. According to the experimental results of this paper, the proportion of community workers is 3.53%.

According to the community data released by the Wuhan Epidemic Prevention and Control Headquarters (http://www.wuhan.gov.cn), a large community in Wuhan contains 5.06 small communities on average. So, we divided the nodes into five small communities. Then, to determine the density of small communities, we first counted the population of 616 small communities in Wuhan and then fitted it with a truncated normal distribution ($\mu = 1943.92,\ \delta = 1193.17$) (Fig. S1). In our experiment, the population distribution of small communities conforms to this truncated normal distribution. The size of the small community is as follows: (816，1110，1821，2166，3739). Household size distributions were taken from the 2019 China National Population Sampling Survey (Fig. S2).

Connections in the network: The average community connection is 4.2, according to the contact surveys [2]. The number of connections in the big community was estimated from the literature [3]. The experimental results in [3] show that when the average distance of the community is 50m, the transmission rate is 36 times that of the distance of 500m. Thus, the average number of connections between the individuals in big community is set to 0.12.

Sensitivity analysis

Sensitivity analysis of the transmission rate parameters $\theta \cdot \beta$ was performed. We take the case where $\theta \cdot \beta = 0.30, 0.42, 0.54$. Fig. S3 shows the size of the epidemic at different transmission rates $\theta \cdot \beta$ without any intervention. Fig. S4 shows the impact of tracing proportions for asymptomatic cases on the outbreak at different transmission rates ($\mu_1 = 3,\ T_i = 30$). Fig. S5 shows the impact of delayed diagnosis time on asymptomatic cases on the outbreak at different transmission rates ($\rho = 75\%,\ T_i = 30$). Fig S6 shows the impact of implementation time for asymptomatic cases on the outbreak at different transmission rates ($\mu_1 = 3,\ \rho = 75\%$).

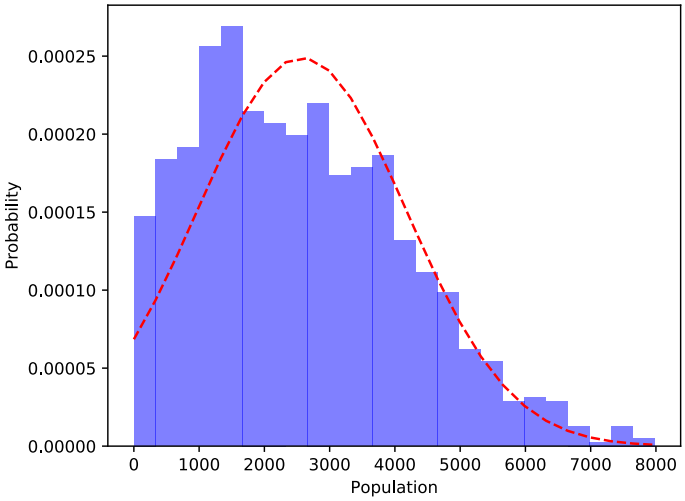

Fig. S1. The distribution of community population size in Wuhan.

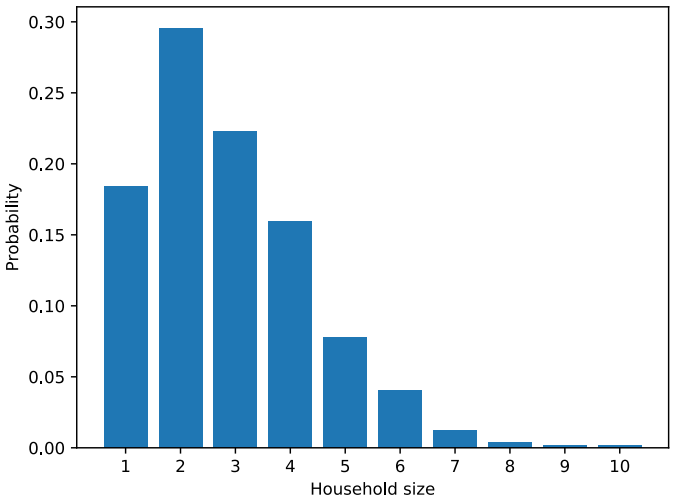

Fig. S2. The distribution of household size in Hubei Province.

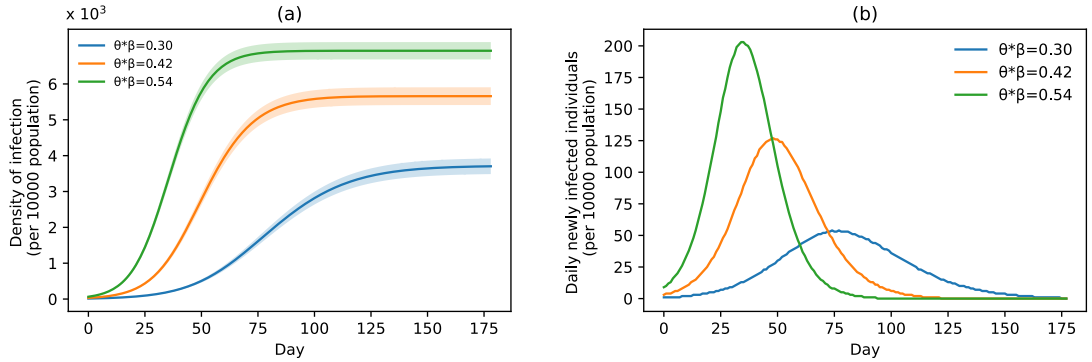

Fig. S3. The impact of transmission rates $\theta \cdot \beta$ on outbreaks without control measures.

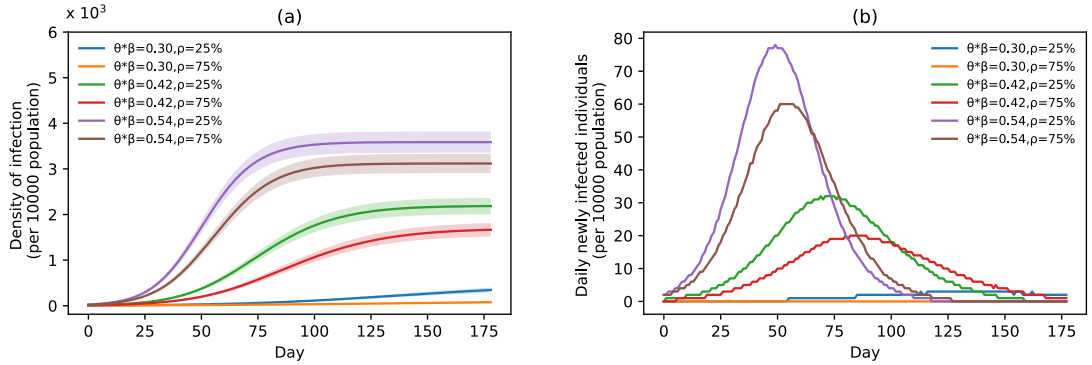

Fig. S4. The impact of tracing proportions for asymptomatic cases on the outbreak at different transmission rates $\theta \cdot \beta$.

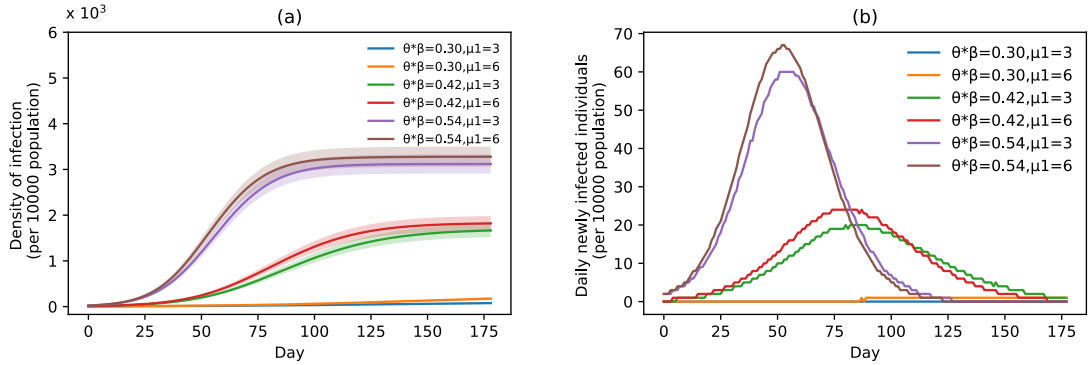

Fig. S5. The impact of delayed diagnosis time on asymptomatic cases on the outbreak at different transmission rates $\theta \cdot \beta$.

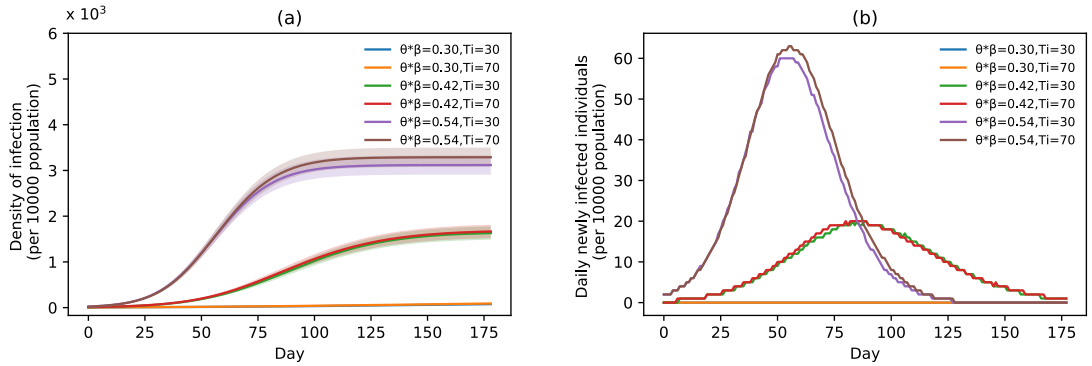

Fig. S6. the impact of implementation time for asymptomatic cases on the outbreak at different transmission rates $\theta \cdot \beta$.

Table 1. Estimated incubation period from selected studies.

Author	Incubation period	Uncertainty	Source
Mike[4]	5.40	4.20-6.70 (95% CI)	NA
Liu et al. [5]	4.80	2.20-7.40	bioRxiv
Akhmetzhanov et al. [6]	5.10	2.00-14.00 (95% CI)	medRxiv
Sun et al.[7]	4.50	3.00–5.50 (IQRs)	The Lancet Digital Health
Read et al.[8]	3.00	0.00-6.00	medRxiv
Li et al.[9]	5.20	4.10-7.00 (95% CI)	NEJM
Guan et al.[10]	3.00	0.00-24.00	medRxiv
Sanche et al.[11]	4.20	3.50-5.10 (95% CI)	medRxiv
Zhang et al.[12]	5.20	1.80-12.40	medRxiv
Tindale et al.[13]	9.00	7.92-10.20 (95% CI)	medRxiv
Ping[14]	8.06	6.89-9.36 (95% CI)	medRxiv
Jing et al.[15]	8.13	7.37-8.91 (95% CI)	medRxiv
Li et al.[16]	3.69	3.28-4.03 (95% CI)	Science
Li et al.[16]	3.6	3.41-3.91 (95% CI)	Science
Li et al.[16]	3.44	3.26-4.06 (95% CI)	Science
Bi et al.[17]	4.80	4.20-5.40 (95% CI)	medRxiv
Guan et al.[18]	4.00	2.00-7.00 (IQRs)	NEJM
Lauer et al.[19]	5.20	4.40-6.00 (95% CI)	medRxiv
Backer et al.[20]	6.40	5.60-7.70 (95% CI)	EuroSurveill

Table 2 Entire data of 300 pairs from 150 communities.

Community ID	Population	Confirmed cases	Infection rates (%)	Date	Confirmed cases	Infection rates (%)	Date	Interval (Days)
1	3891	4	0.103	2020/2/9	6	0.154	2020/2/15	6
2	3852	3	0.078	2020/2/14	6	0.156	2020/2/20	6
3	3096	3	0.097	2020/2/14	6	0.194	2020/2/18	4
4	2634	6	0.228	2020/2/14	8	0.304	2020/2/18	4
5	3114	8	0.257	2020/2/14	9	0.289	2020/2/18	4
6	6156	8	0.130	2020/2/14	13	0.211	2020/2/18	4
7	18483	100	0.541	2020/2/15	107	0.579	2020/2/17	2
8	3927	3	0.076	2020/2/14	6	0.153	2020/2/23	9
9	8872	27	0.304	2020/2/12	41	0.462	2020/2/20	8
10	1797	4	0.223	2020/2/14	5	0.278	2020/2/17	3
11	9540	11	0.115	2020/2/9	22	0.231	2020/2/14	5
12	7872	5	0.064	2020/2/13	6	0.076	2020/2/16	3
13	6606	8	0.121	2020/2/9	12	0.182	2020/2/22	13
14	24294	6	0.025	2020/2/12	7	0.029	2020/2/15	3
15	12000	21	0.175	2020/2/10	22	0.183	2020/2/12	2
16	18000	11	0.061	2020/2/9	15	0.083	2020/2/12	3
17	11237	7	0.062	2020/2/10	13	0.116	2020/2/14	4
18	6741	6	0.089	2020/2/11	8	0.119	2020/2/14	3
19	12915	15	0.116	2020/2/11	17	0.132	2020/2/18	7
20	2001	2	0.100	2020/2/14	5	0.250	2020/2/23	9
21	2352	2	0.085	2020/2/14	4	0.170	2020/2/23	9
22	4518	6	0.133	2020/2/10	9	0.199	2020/2/14	4
23	9756	10	0.103	2020/2/11	13	0.133	2020/2/15	4
24	8328	5	0.060	2020/2/14	6	0.072	2020/2/16	2
25	5949	12	0.202	2020/2/13	20	0.336	2020/2/21	8
26	1488	3	0.202	2020/2/13	6	0.403	2020/2/21	8
27	19557	28	0.143	2020/2/17	34	0.174	2020/2/25	8
28	7083	3	0.042	2020/2/12	5	0.071	2020/2/14	2
29	2478	2	0.081	2020/2/7	4	0.161	2020/2/12	5
30	8637	24	0.278	2020/2/14	30	0.347	2020/2/24	10
31	8679	27	0.311	2020/2/10	61	0.703	2020/2/16	6
32	23142	49	0.212	2020/2/14	54	0.233	2020/2/17	3
33	4350	4	0.092	2020/2/12	6	0.138	2020/2/18	6
34	4280	29	0.678	2020/2/14	31	0.724	2020/2/15	1
35	516	1	0.194	2020/2/10	3	0.581	2020/2/16	6
36	1746	2	0.115	2020/2/17	4	0.229	2020/2/23	6
37	4644	11	0.237	2020/2/9	20	0.431	2020/2/17	8

38	6340	24	0.379	2020/2/13	27	0.426	2020/2/15	2
39	7819	14	0.179	2020/2/9	39	0.499	2020/2/14	5
40	6246	23	0.368	2020/2/12	25	0.400	2020/2/14	2
41	7234	15	0.207	2020/2/12	20	0.277	2020/2/14	2
42	7106	26	0.366	2020/2/12	30	0.422	2020/2/14	2
43	5570	33	0.592	2020/2/12	38	0.682	2020/2/14	2
44	8781	25	0.285	2020/2/12	26	0.296	2020/2/14	2
45	5802	28	0.483	2020/2/12	34	0.586	2020/2/14	2
46	5541	20	0.361	2020/2/12	23	0.415	2020/2/14	2
47	3493	4	0.115	2020/2/13	5	0.143	2020/2/17	4
48	1140	7	0.614	2020/2/9	11	0.965	2020/2/13	4
49	1770	1	0.056	2020/2/14	3	0.170	2020/2/18	4
50	5934	1	0.017	2020/2/4	3	0.051	2020/2/10	6
51	2511	2	0.080	2020/2/10	4	0.159	2020/2/16	6
52	5058	5	0.099	2020/2/12	7	0.138	2020/2/17	5
53	4602	2	0.043	2020/2/13	4	0.087	2020/2/17	4
54	6642	8	0.120	2020/2/11	10	0.151	2020/2/12	1
55	2142	7	0.327	2020/2/8	8	0.374	2020/2/9	1
56	9030	23	0.255	2020/2/15	38	0.421	2020/2/23	8
57	12348	5	0.040	2020/2/12	7	0.057	2020/2/15	3
58	7004	22	0.314	2020/2/11	24	0.343	2020/2/13	2
59	1398	22	1.574	2020/2/17	24	1.717	2020/2/22	5
60	11274	20	0.177	2020/2/11	22	0.195	2020/2/14	3
61	11674	28	0.240	2020/2/12	44	0.377	2020/2/21	9
62	9576	17	0.178	2020/2/14	23	0.240	2020/2/25	11
63	3114	11	0.353	2020/2/11	17	0.546	2020/2/22	11
64	1950	1	0.051	2020/2/17	3	0.154	2020/2/23	6
65	11778	4	0.034	2020/2/12	5	0.043	2020/2/14	2
66	8310	8	0.096	2020/2/10	14	0.169	2020/2/14	4
67	7608	13	0.171	2020/2/9	28	0.368	2020/2/15	6
68	12537	26	0.207	2020/2/13	28	0.223	2020/2/24	11
69	1914	3	0.157	2020/2/9	4	0.209	2020/2/13	4
70	6987	11	0.157	2020/2/9	13	0.186	2020/2/13	4
71	4434	1	0.023	2020/2/9	2	0.045	2020/2/13	4
72	14724	10	0.068	2020/2/13	14	0.095	2020/2/16	3
73	1392	11	0.790	2020/2/10	17	1.221	2020/2/14	4
74	1764	13	0.737	2020/2/14	19	1.077	2020/2/19	5
75	4728	19	0.402	2020/2/11	22	0.465	2020/2/22	11
76	9279	28	0.302	2020/2/12	32	0.345	2020/2/14	2
77	3765	1	0.027	2020/2/10	2	0.053	2020/2/11	1
78	1440	14	0.972	2020/2/14	31	2.153	2020/2/21	7
79	8208	17	0.207	2020/2/12	19	0.232	2020/2/16	4
80	13094	8	0.061	2020/2/8	14	0.107	2020/2/15	7

81	6282	2	0.032	2020/2/15	5	0.080	2020/2/24	9
82	7350	18	0.245	2020/2/13	31	0.422	2020/2/15	2
83	3246	25	0.770	2020/2/15	28	0.863	2020/2/17	2
84	8970	10	0.111	2020/2/14	11	0.123	2020/2/16	2
85	5738	12	0.209	2020/2/9	19	0.331	2020/2/12	3
86	7115	6	0.084	2020/2/15	15	0.211	2020/2/17	2
87	8642	11	0.127	2020/2/10	13	0.150	2020/2/13	3
88	5512	24	0.435	2020/2/12	34	0.617	2020/2/20	8
89	6261	8	0.128	2020/2/9	17	0.272	2020/2/12	3
90	16000	24	0.150	2020/2/12	36	0.225	2020/2/17	5
91	5310	14	0.264	2020/2/14	19	0.358	2020/2/21	7
92	1980	7	0.354	2020/2/11	8	0.404	2020/2/14	3
93	3042	14	0.460	2020/2/16	16	0.526	2020/2/19	3
94	3252	1	0.031	2020/2/16	3	0.092	2020/2/20	4
95	1782	1	0.056	2020/2/12	3	0.168	2020/2/16	4
96	6664	3	0.045	2020/2/15	5	0.075	2020/2/20	5
97	8372	32	0.382	2020/2/14	34	0.406	2020/2/17	3
98	10347	5	0.048	2020/2/15	6	0.058	2020/2/18	3
99	9300	27	0.290	2020/2/8	33	0.355	2020/2/14	6
100	4110	7	0.170	2020/2/11	9	0.219	2020/2/14	3
101	9930	26	0.262	2020/2/15	28	0.282	2020/2/17	2
102	5736	9	0.157	2020/2/14	11	0.192	2020/2/23	9
103	16336	49	0.300	2020/2/14	51	0.312	2020/2/17	3
104	3978	6	0.151	2020/2/10	7	0.176	2020/2/14	4
105	16203	10	0.062	2020/2/13	10	0.062	2020/2/16	3
106	1446	2	0.138	2020/2/10	3	0.208	2020/2/16	6
107	7392	10	0.135	2020/2/11	12	0.162	2020/2/13	2
108	10224	4	0.039	2020/2/13	6	0.059	2020/2/17	4
109	11394	8	0.070	2020/2/9	11	0.097	2020/2/19	10
110	1380	5	0.362	2020/2/14	13	0.942	2020/2/21	7
111	9315	8	0.086	2020/2/9	13	0.140	2020/2/19	10
112	10287	12	0.117	2020/2/10	15	0.146	2020/2/13	3
113	5502	21	0.382	2020/2/10	26	0.473	2020/2/13	3
114	4374	6	0.137	2020/2/9	8	0.183	2020/2/13	4
115	1341	2	0.149	2020/2/12	4	0.298	2020/2/16	4
116	1950	6	0.308	2020/2/10	10	0.513	2020/2/14	4
117	3840	1	0.026	2020/2/15	4	0.104	2020/2/16	1
118	4947	7	0.141	2020/2/12	8	0.162	2020/2/13	1
119	3960	3	0.076	2020/2/12	5	0.126	2020/2/21	9
120	7122	2	0.028	2020/2/13	5	0.070	2020/2/15	2
121	10374	14	0.135	2020/2/10	35	0.337	2020/2/19	9
122	3342	2	0.060	2020/2/14	3	0.090	2020/2/21	7
123	9120	2	0.022	2020/2/9	10	0.110	2020/2/22	13

124	3288	2	0.061	2020/2/14	4	0.122	2020/2/21	7
125	7434	16	0.215	2020/2/12	20	0.269	2020/2/24	12
126	9404	2	0.021	2020/2/10	3	0.032	2020/2/15	5
127	7575	19	0.251	2020/2/12	23	0.304	2020/2/14	2
128	5652	5	0.088	2020/2/10	7	0.124	2020/2/14	4
129	2622	4	0.153	2020/2/10	6	0.229	2020/2/14	4
130	2610	2	0.077	2020/2/10	3	0.115	2020/2/14	4
131	7484	14	0.187	2020/2/10	16	0.214	2020/2/13	3
132	2682	3	0.112	2020/2/16	9	0.336	2020/2/24	8
133	8896	25	0.281	2020/2/14	36	0.405	2020/2/19	5
134	2488	19	0.764	2020/2/10	39	1.568	2020/2/19	9
135	5399	11	0.204	2020/2/13	15	0.278	2020/2/18	5
136	1785	6	0.336	2020/2/15	9	0.504	2020/2/16	1
137	9514	13	0.137	2020/2/14	15	0.158	2020/2/17	3
138	9038	10	0.111	2020/2/13	14	0.155	2020/2/16	3
139	6552	5	0.076	2020/2/14	7	0.107	2020/2/20	6
140	3918	5	0.128	2020/2/9	7	0.179	2020/2/13	4
141	3323	27	0.813	2020/2/3	55	1.655	2020/2/8	5
142	13050	27	0.207	2020/2/3	55	0.422	2020/2/8	5
143	11210	22	0.196	2020/2/3	32	0.286	2020/2/8	5
144	6844	21	0.307	2020/2/3	32	0.468	2020/2/8	5
145	16336	17	0.104	2020/2/3	34	0.208	2020/2/8	5
146	9745	15	0.154	2020/2/3	31	0.318	2020/2/8	5
147	10849	14	0.129	2020/2/3	29	0.267	2020/2/8	5
148	7921	14	0.177	2020/2/3	30	0.379	2020/2/8	5
149	10812	14	0.129	2020/2/3	37	0.342	2020/2/8	5
150	4559	12	0.263	2020/2/3	41	0.899	2020/2/8	5

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