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Short Communication

Monitoring disease transmissibility of 2019 novel coronavirus disease in Zhejiang, China◇

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ABSTRACT

Owing to the frequent travel connections between Wuhan and Zhejiang, Zhejiang was the third worst-affected province in China with 1,205 cases confirmed before 26 February 2020. The transmissibility of the 2019 novel coronavirus disease was monitored in Zhejiang, accounting for the transmissions from imported cases. Even though Zhejiang was one of the worst-affected provinces, an interruption of disease transmission (i.e. instantaneous reproduction numbers <1) was observed in early/mid-February after a comprehensive set of interventions combating the outbreak.

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In December 2019, a novel strain of coronavirus emerged and caused an outbreak in Wuhan, Hubei province, China (WHO, 2020). The disease responsible for the outbreak has been officially named by the World Health Organization (WHO) as COVID-19. To halt the spread of COVID-19, the Chinese government announced a complete lockdown in Wuhan on 23 January 2020. A set of draconian countermeasures were issued to other cities in Hubei province since 26 January 2020, aiming to quarantine the epicentre of the outbreak (Amy and Wuhan, 2020). Owing to the frequent travel connections between Wuhan and Zhejiang (an eastern province with 57 million residents), Zhejiang was the third worst-affected province with 1,205 cases confirmed before 26 February 2020, and the first province to declare the highest provincial level public health emergency in response to the outbreak (23 January 2020). As of 27 January 2020, Zhejiang released many travel-related measures by suspending all inter-province land and water passenger transportation. Starting from 1 February to 6 February 2020, all 11 cities in Zhejiang imposed a comprehensive set of interventions–including personal protective measures, environmental measures, social distancing measures, and city-level travel restrictions–to mitigate the risk and impact of the COVID-19 epidemic. In 10 of the 11 Zhejiang cities, arrivals with a travel history to other provinces within the last 14 days were quarantined; individuals were requested to stay at home for at least 2 weeks and immediately report any fever or cough cases to their neighbourhood committee (*cunweihui* and *juweihui*); enforced temperature check and face mask wearing were applied in public places to protect the people; gatherings, including weddings, were suspended to keep social distance; and it was suggested that only one person per household leave home once every 2 days for supplies (Hangzhou Municipal Health Commission, 2020). In addition to these measures, more restrictive interventions were applied for Wenzhou city, which was most affected by the epidemic. All factories and schools were shut down; inter-city and intra-city public transportation were mostly suspended; transportation hubs were frequently sterilized; and no inter-community movement was allowed without necessary reasons (Wenzhou Government Information, 2020). This type of comprehensive intervention was widely applied in many provinces in China, while Zhejiang was one of the very first to apply these measures outside Hubei.

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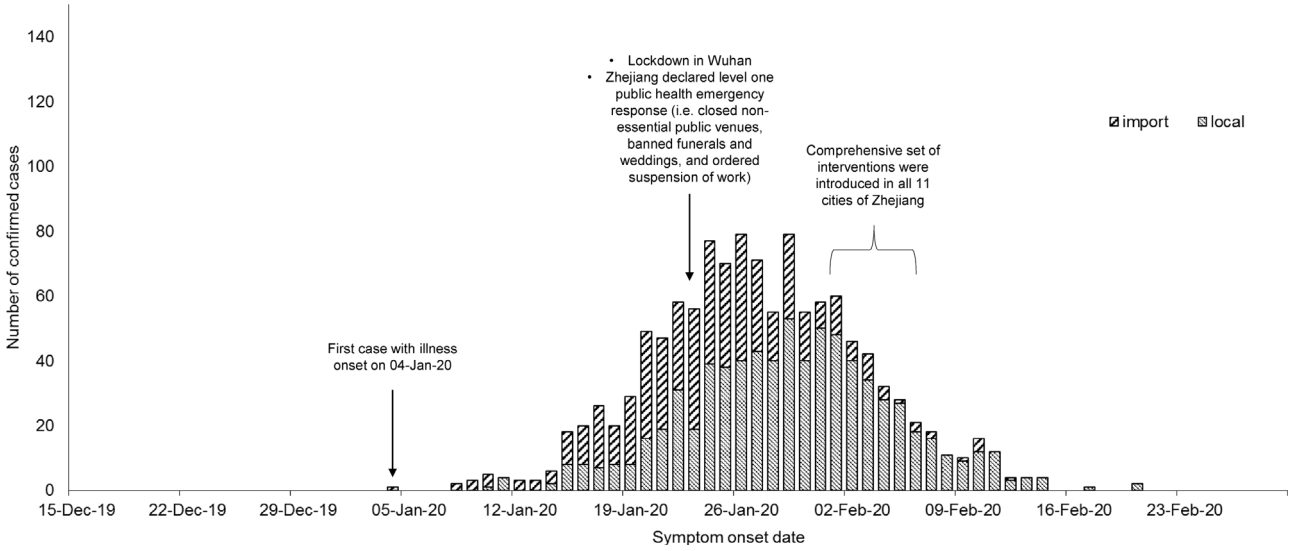

Fig. 1. Number of imported cases and local cases of COVID-19 in Zhejiang against symptom-onset date.

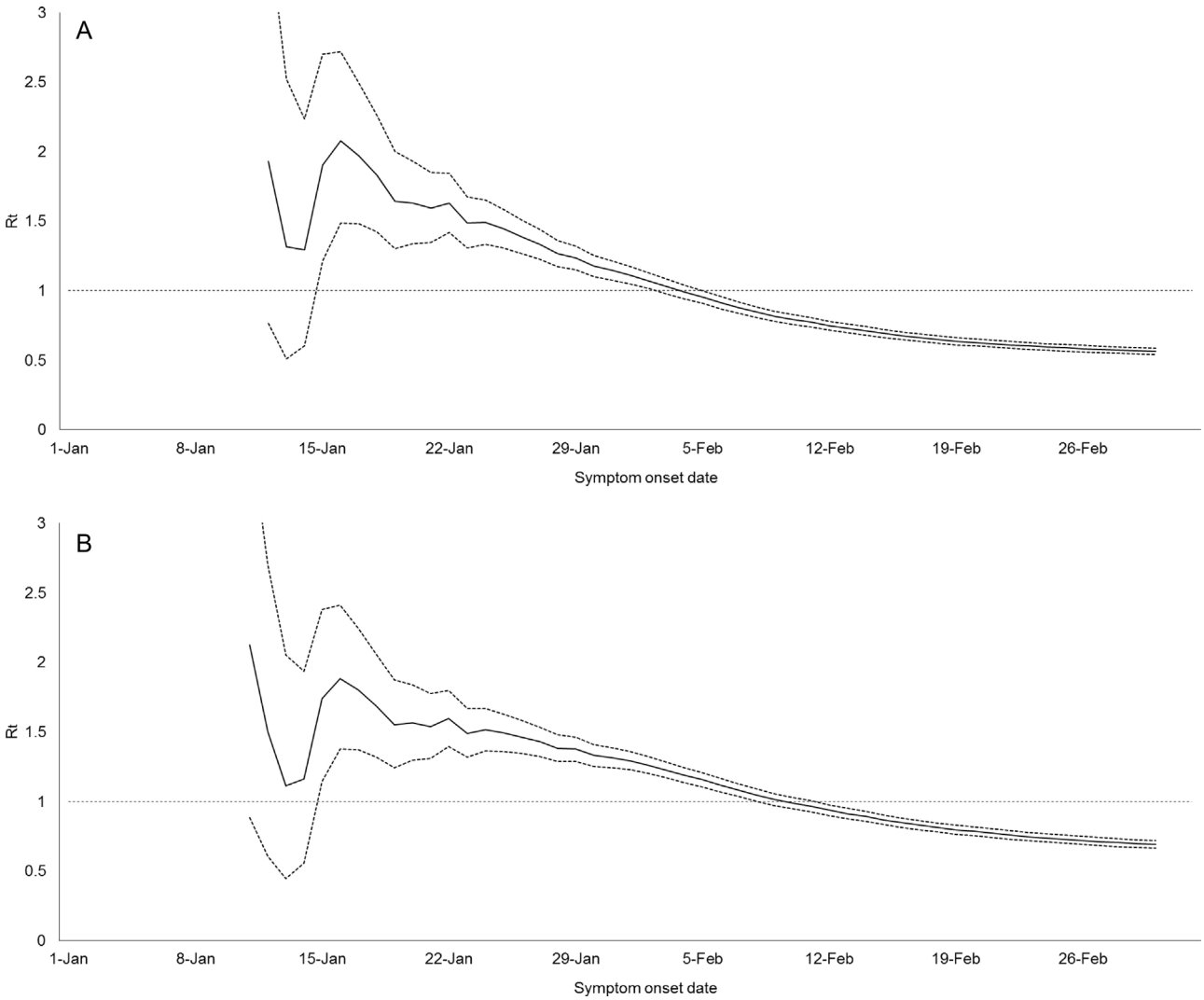

Fig. 2. Estimated instantaneous reproduction number (R_t) (solid line) and 95% confidence intervals (dotted lines) using: (A) Wallinga and Teunis approach (M1); and (B) susceptible-exposed-infectious-recovered (SEIR) model-based approach.

The instantaneous reproduction number (R_t) of COVID-19 in Zhejiang was estimated to monitor the impact of control measures on disease transmissibility over time. R_t was defined as the average number of secondary cases generated by a primary case at time t in a population and is a time-varying measure of disease transmissibility when intervention measures are in place for outbreak control (De Serres et al., 2000). If R_t is below unity, disease transmission is unlikely to be sustained and the outbreak should be under control. The data of confirmed cases, including both local and imported cases from 26 December 2019 to 25 February 2020, from all cities in Zhejiang were analysed. Cases with travel history to other provinces (with $\geq$1 case reported) 14 days prior to symptom onset were defined as imported cases. To ensure a robustness of estimation, two different methods were used to estimate R_t: 1) Wallinga and Teunis approach (M1) (Wallinga and Teunis, 2004; Cori et al., 2013) and 2) susceptible-exposed-infectious-recovered (SEIR) model-based approach (M2). In M1, it was assumed that the serial interval followed a lognormal distribution with a mean of 7.5 days and standard deviation of 3.4 days (Li et al., 2020), whereas in M2, the mean latent duration and mean infectious duration were assumed to be 5.2 (Li et al., 2020) and 2.3 days (i.e. difference between mean serial interval and mean latent duration), respectively. Using the time series data of local and imported cases, the likelihoods were formulated and the model parameter R_t was solved (additional details in Supplementary File).

Over the study period, R_t attained peak values of 2.08 (95% CI 1.49 to 1.72) and 1.88 (95% CI 1.38 to 2.41) on 16 January 2020 for method M1 and method M2, respectively (Figs. 1 and 2). The R_t remained stable and kept above 1.40 until 28 January 2020, 5 days after the declaration of the highest-level public health emergency. Although the number of local cases had gradually surpassed that of imported cases, the R_t decreased over time. After the lockdown of cities, the upper bounds of CI of R_t for M1 and M2 were below the threshold of unity on 6 February 2020 and 12 February 2020, respectively: M1 0.91 (95% CI 0.87 to 0.96) and M2 0.94 (95% CI 0.90 to 0.98). The R_t was to be 0.63 (95% CI 0.60 to 0.65) for M1 and 0.78 (95% CI 0.75 to 0.82) for M2 on 20 February 2020, the day the last cases were reported to date. The trends of R_t were generally not sensitive when the mean infectious duration varied but with a shorter infectious duration, a later of time for R_t being below unity (Figure S1 in Supplementary File).

Taking transmission arising from imported cases into account, disease transmissibility of COVID-19 reached its peak on 16 January 2020, before Zhejiang declared the highest-level public health emergency and the government imposed a lockdown in Wuhan. A fast growth in disease transmission during the initial phase of this epidemic can thus be expected, especially in areas that have tight travel connections with the source region (Zhao et al., 2020). With the successive imported cases from Wuhan, the local infections were likely to be generated by them and this resulted in sustained transmission initially in Zhejiang, as indicated by $R_t > 1$. Because of this, it is advised that early and strict screening and tracing measures be implemented before a large number of imported cases arises in a community, for example, mandatory quarantine for travellers to the region. In addition, this study showed that the transmission of COVID-19 reduced and remained at a low level, not only after the lockdown of Wuhan, after the implementation of a comprehensive set of interventions in Zhejiang. As a result, disease transmission in the population was interrupted ($R_t < 1$) within several weeks alongside a drop in local cases. The decline in transmissibility might be attributed to the early declaration of a public health emergency, followed by implementation of large-scale measures, which seemed to interrupt and slow down the transmission of COVID-19 in the population. These findings could thus inform high-risk regions on disease control planning in a timely manner.

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Conflict of interest

No conflict of interest to declare.

Ethical approval

As this investigation was a part of the surveillance of emerging infectious diseases of Zhejiang Provincial Center for Disease Control and Prevention (CDC), ethics approval and informed consent were exempted by CDC. The data were analysed anonymously.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.ijid.2020.04.036.

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