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Letter to the Editor

Impact of non-pharmaceutical interventions during COVID-19 pandemic on pertussis, scarlet fever and hand-foot-mouth disease in China



Dear Editor,

A recent study reported that the incidence of rotavirus infection in Hangzhou of China is reduced greatly in the 2020 than that of the last two years, possibly due to non-pharmaceutical interventions (NPIs) implemented during the COVID-19 pandemic in China¹. In 2021, except for the sporadic outbreaks in certain areas, China began to ease the protective NPIs. The strict social distancing rules were relaxed as school or kindergarten open. Moreover, the awareness of hygiene and protection such as personal hygiene, and mask-wearing was slack. Pertussis, scarlet fever and hand-foot-mouth disease (HFMD) are three common childhood infectious diseases. The incidence trends in China for these three infectious diseases during 2020 and 2021 remains inclusive.

Pertussis, caused by *Bordetella pertussis* or *Bordetella parapertussis*, is a highly infectious acute respiratory disease, resulting in high morbidity and mortality in childhood, especially in infants who have weak immunity. Scarlet fever is an exotoxin-mediated childhood exanthem caused by *Streptococcus pyogenes* and transmitted by airborne droplets and contact with contaminants. For HFMD caused by the human enterovirus within the *Picornaviridae* family, it has multiple known routes of transmission, including indirect contact, alimentary tract, and the respiratory tract². Given the harm to public health caused by these diseases, we should pay close attention to the epidemiologic dynamics and are scrambling to find critical more effective intervention and prevention strategies to deal with these resurgent infectious diseases.

We compared the reported cases and incidence of the three common contagious diseases in China before and after the COVID-19 pandemic to explore the impact of NPIs during the pandemic on these infectious diseases. The monthly case data of the infectious diseases mentioned above from January 2017 to October 2021 was extracted from the Disease Surveillance system administered by the National Health Commission of the People's Republic of China (www.nhc.gov.cn). The incidence rate *per* one hundred thousand populations was calculated based on the annual total population of the China Population Statistical Yearbook, 2021. The national population is estimated at about 14 billion for the disease incidence in the first 10 months of 2020 and 2021. Data analysis and visualization were performed in statistical software (Prism 9.0, GraphPad Software). Chi-square test or Fisher's exact test was used to compare morbidity across different groups.

From the shape of the curve, we can see that the overall trend of the three infectious diseases is broadly similar. The curves for them in 2020 are obvious to flatten with the strongest possible mitigation compared with previous years and appear an apparent

rise in 2021 (Fig. 1A, 1B and 1C). Compared the annual reported cases in 2020 with the average annual reported cases from 2017 to 2019, the increment rate is 76.49%, 78.26% and 63.20% for pertussis, scarlet fever and HFMD, respectively. The highest increment rate of the number of reported cases in the first ten months of 2020 compared with that in the first ten months of 2021 is 163.10% for HFMD, flowed by 81.18% for scarlet fever and 30.64% for pertussis Fig. 1D, (Table 1).

From 2017 to 2019, the average number of the reported cases of pertussis was 21,245 with an annual incidence of 1.51 while the number for 2020 was only 4994 with an incidence of 0.35 ($P < 0.001$). Meanwhile, compared with an incidence of 0.31 in the first ten months of 2020, the annual incidence increased to 0.41 in the first ten months of 2021 ($P < 0.001$). Similar to the trend from pertussis, there was an obvious decline in the annual incidence of 2020 (1.22 for scarlet fever and 54.49 for HFMD) and a sharp rebound in the annual incidence for the first ten months of 2021 (1.63 for scarlet fever and 84.31 for HFMD) for scarlet fever and HFMD. Compared to the annual incidence in average 2017–2019 (5.63 for scarlet and 148.79 for HFMD), there was statistical difference regarding the decline in the annual incidence of 2020 ($P < 0.001$). The difference of the annual incidence between the first ten months of 2020 and 2021 was also statistically significant for both scarlet fever and HFMD ($P < 0.001$) (Table 1).

When the strict social distancing rules were relaxed as school and kindergarten were open after June 2020, both the scarlet fever and HFMD increased rapidly while pertussis remained at low levels with small fluctuations. At the same time, the absolute growth rate of HFMD in 2020 was the smallest and largest in 2021. We speculate on several reasons for this phenomenon. First, the route of HFMD transmission is more than scarlet fever and pertussis. Second, the reproduction number for HFMD ($R_0=15.8-30.1$) is also higher than scarlet fever ($R_0=5-8$) and pertussis ($R_0=12-17$)³⁻⁵. The effectiveness of NPIs in reducing the infection reproductive ratio heavily dependent on the pre-intervention basic reproductive ratio⁶.

Our research shows that the protective NPIs during the COVID-19 pandemic in 2020 significantly reduced the number of reported cases and incidence of the three common infectious diseases in childhood. As described above, they are all communicable diseases that can be spread through the respiratory tract. In addition, the scarlet fever is thought to spread easily in close proximity environment of classrooms or workplace settings⁷. Thus, implementation of school closure, social distancing measurements, and movement restrictions during NPIs can reduce the infected risk, leading to the decline in reported cases. The effect of reduction in the number of reported cases produced by NPIs is consistent with two recent reports^{8,9}. In 2021, the number of reported cases as well as the incidence of the three common infectious diseases rebound substantially as the comprehensive intervention policies relaxed in 2021.

Table 1
National epidemiological data of pertussis, scarlet fever, and hand-foot-mouth disease in children from 2017 to 2021.

Category	2017–2019		2020		2020 VS 2017–2019		2020 (In the first 10 months)		2021 (In the first 10 months)		2021 VS 2020	
	Number of reported cases	Incidence rate (/100,000)	Number of reported cases	Incidence rate (/100,000)	Increase cases	Increase rate (95%CI)	Number of reported cases	Incidence rate (/100,000)	Number of reported cases	Incidence rate (/100,000)	Increase cases	Increase rate (95%CI)
Pertussis	21,245	1.51	4994	0.35	–16,251	–76.49% (–77.06 to –75.92)	4409	0.31	5760	0.41	1351	30.64% (29.28 to 32.00)
Scarlet fever	79,137	5.63	17,206	1.22	–61,931	–78.26% (–78.55 to –77.97)	12,588	0.90	22,807	1.63	10,219	81.18% (80.50 to 81.86)
Hand-foot-mouth disease	2,090,803	148.79	769,450	54.49	–1,321,353	–63.20% (–63.26 to –63.13)	448,635	32.05	1,180,350	84.31	731,715	163.10% (162.96 to 163.24)

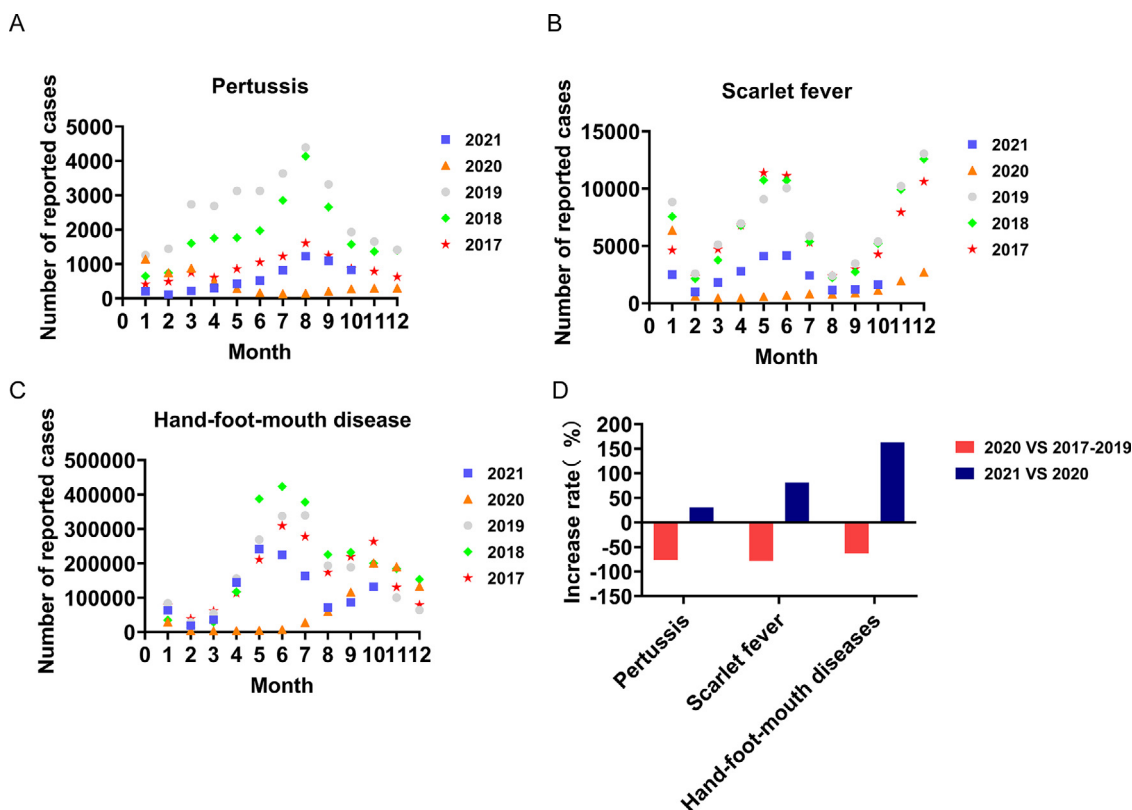


Fig. 1. Numbers of reported cases and increase rate of pertussis, scarlet fever and hand-foot-mouth disease from 2017 to 2020 in China. A. Reported cases of pertussis. B. Reported cases of scarlet fever. C. Reported cases of hand-foot-mouth disease. D. Increase rate of pertussis, scarlet fever and hand-foot-mouth disease.

These data further confirmed the protective effect of these comprehensive NPIs such as strict social distance, personal hygiene, mask-wearing etc. against these childhood infectious diseases.

In summary, we showed that the significant reduction in the number of reported cases and the incidence of pertussis, scarlet fever and HFMD was associated with intervention strategies. The NPIs have a protective effect for them and can contribute towards bringing the epidemic of these common infectious pathogens under control.

Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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