Non-pharmaceutical interventions used to control COVID-19 reduced seasonal influenza transmission in China

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Abstract

To suppress the ongoing COVID-19 pandemic, the Chinese government has implemented a set of non-pharmaceutical interventions (NPIs). Because COVID-19 and influenza have similar means of transmission, it is hypothesized that NPIs targeting COVID-19 may also affect influenza transmission. In this study, the extent to which NPIs targeting COVID-19 have affected seasonal influenza transmission was explored. Indicators of seasonal influenza activity in the epidemiological year 2019/20 were compared with those in 2017/18 and 2018/19. Results show that the incidence rate of seasonal influenza reduced by 64% in 2019/20 (p<0.001). These findings suggest that NPIs aimed at controlling COVID-19 significantly reduced the seasonal influenza transmission in China. (105 words)

Keywords. Non-pharmaceutical interventions, influenza, COVID-19, incidence.

Background

In December 2019, a novel coronavirus named severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), led to a pandemic of coronavirus disease 2019 (COVID-19) [0]. To suppress the COVID-19 pandemic, from January 23-25, 2020, 30 provinces began a 1-level response and implemented a set of non-pharmaceutical interventions (NPIs), including not only the classical isolation of the confirmed/suspected cases and quarantine of their close contacts in special facilities, but also unprecedented measures like strict community containments with social distancing, such as the Wuhan city travel ban to prevent the exportation of cases from Wuhan and other priority areas of Hubei Province, extension of the Spring Festival holiday, suspension of traffic and transportation, closure of school and entertainment venues, banning of mass gathering activities, compulsory community use of facemasks in public areas, and information about the epidemic and prevention measures widely disseminated, public risk communications and health education strengthened, new hospital built to ensure that all cases could be treated [2].

Both COVID-19 and seasonal influenza are respiratory infections and mainly transmitted via respiratory droplets and contact routes [3-5] . In addition, Northern China experiences influenza epidemics concentrated in winter-spring months, while Southern China experiences a semi-annual cyclic pattern with clear peaks in both summer and winter. In both Southern and Northern China in the winter-spring months, the seasonal influenza epidemics always peak in January–February [6], so months in which in 2020, the COVID-19 pandemic overlapped with the flu season in the winter-spring months in China. It is postulated that the population-wide NPIs implemented to contain COVID-19 would also have effects on seasonal influenza. Two studies conducted in Singapore and Taiwan, China have reported a reduction in influenza activity during the COVID-19 pandemic period [7, 8]. Compared with these two regions, Mainland China has significantly more COVID-19 cases and has implemented stricter NPIs, including massive mobility restrictions, universal fever screen, use of big data and artificial intelligence to strengthen contact tracing and the management of priority populations [2]. This study is significant because it showcases a country that has experienced a relatively high COVID-19 caseload and has implemented an intensive package of NPIs. By examining how NPIs targeting COVID-19 affect the transmission of seasonal influenza epidemics in China, the study may help other countries to plan for the dual burden of COVID-19 and influenza in the future.

Methods

In this study, weekly reports of influenza cases from years 2017 to 2020 from the Chinese National Influenza Center were used. The dataset provided the number of visits, the number of influenza like illness (ILI) cases, and the number of specimens tested, the number of laboratory-confirmed influenza cases, in 554 sentinel hospital. The standard case definition of ILI, is a body temperature ≥38°C with either cough or sore throat, in the absence of an alternative diagnosis [6]. Please refer to Shu et al. [9] for additional details about the Chinese influenza surveillance system. Since China is located in the Northern Hemisphere, an epidemiological annual cycle was defined as the period from October 1st (calendar week 40, epidemiological week 1 as noted in this study) to September 31st in the next year [6], i.e. epidemiological year 2018/19 refers to the period from October 1, 2018 to September 30, 2019, while the epidemiological year 2019/20 only went until epidemiological week 34, i.e. May 24, 2020, when this study stared.

Several indicators were defined to characterize influenza activity in China. First, the ILI rate was defined as the number of ILI cases divided by the number of visits. Second, the influenza viral positive rate was defined as the number of laboratory-confirmed influenza cases divided by the number of specimens tested. Third, the incidence rate was defined as the ILI rate among the visiting patients in sentinel hospitals multiplied by the influenza viral positive rate, a count more precisely representing the influenza infections [10,]. The weekly incidence rate was then interpolated to daily incidence rate using splines [11]. Changes in transmissibility were estimated over time using the effective reproductive number, Rt. Time-varying estimates of the daily effective reproductive number were made using the ***R*** package EpiEstim, assuming a mean serial interval of 2.85 days and a standard deviation of 0.93 days [12]. Estimates of Rt were conducted with ***R*** version 3.6.3 (***R*** Foundation for Statistical Computing).

Indictors of influenza activity in the year 2019/20 were compared with the average from the corresponding period in the two preceding epidemiological years. Paired difference T-tests were performed using Excel.

Results

Compared with the epidemiological years 2017/18 and 2018/19, the number of outpatient visits was a lightly higher in the epidemiological year 2019/20 before NPIs implementations ($\boldsymbol{p}<0.001$). From January 23, 2020, it would be reasonable to expect a rapid decrease of the outpatient visits due to the COVID-19 pandemic Indeed, results show that when compared with the same period during epidemiological year 2017/18-2018/19, the number of outpatient visits decreased by 56% in the 4 weeks following NPIs implementations ($\boldsymbol{p}<0.001$) (Figure 1A). However, because of the similarities in symptoms between COVID-19 and influenza, the number of samples tested per week only decreased by 28% ($\boldsymbol{p}<0.001$) (Figure 1B), and there were no significant changes in ILI rate ($\boldsymbol{p}=0.117$) (Figure 1C). In contrast, the influenza positive rate in samples in the epidemiological year 2019/20 decreased by 79% ($\boldsymbol{p}<0.001$) (Figure 1D).

In the epidemiological year 2019/20, influenza incidence rates peaked on epidemiological week 13, and there was no significant difference with the mean influenza incidence rates in epidemiological year 2017/18 and 2018/19 (***p***=0.496) before NPIs implementation (Figure 2A). When the NPIs were implemented to contain COVID-19, the influenza incidence rates declined rapidly to below the average of the preceding two years, and it reached almost 0 within 7 weeks after the NPIs implementation (Figure 2A). The mean incidence rate reduced by 64% compared with the preceding two years (***p***<0.001). There was also a significant decrease in the daily effective reproductive number in epidemiological year 2019/20 in the 3-4 weeks after the NPIs were implemented to control the COVID-19 pandemic compared with the preceding two years (***p***<0.001) (Figure 2B). Five or more weeks after the NPIs implementation, influenza activity reached a very low level (Figure 2A).

Discussion

Some of the NPIs used to control COVID-19,such as school closure [13], community use of facemasks and hand hygiene [14], have been shown to be effective against influenza epidemics. Therefore, it's not surprising that these NPIs, when used to control COVID-19, would also reduce the seasonal influenza transmission in China. However, what was unexpected from this study was the extent to which the NPIs reduced influenza transmission. The study showed that the mean incidence rate of influenza reduced by 64% in the epidemiological year 2019/20 after implementing after the implementation of NPIs to prevent COVID-19. The reduction of 64% is significantly higher than the reported efficiency of single interventions used against influenza epidemics in the past, such as school closure (16–18% reduction of seasonal influenza cases) [13] and community use of facemasks (35% reduction of ILI cases at most) [14]. This suggests that there may be a synergistic effect of deploying multiple NPIs at the same time. It also suggests that certain NPIs which have been uniquely utilized during the COVID-19 pandemic, such as suspending public transport by bus and subway rail, might also be effective against seasonal influenza epidemics.

Healthcare avoidance during the COVID-19 pandemic may be an important confounder for the results presented. However, it is unlikely that this confounding effect is significant for a number of reasons. First, in order to contain the COVID-19 pandemic, the government encouraged people with ILI to seek medical care in order to obtain a diagnosis., In addition, the influenza laboratories based on different levels of CDC ensured the appropriate influenza testing capacity for differential diagnosis with SARS-Cov-2. Lastly, and the most important, healthcare avoidance did not explain the lower influenza positive rate in the tested samples (Figure 1D). Therefore, the evidence strongly suggests that the decreasing incidence rate of seasonal influenza in China was the result of the strict NPIs implemented in response to COVID-19.

There are two main limitations of this study. The first limitation is that there was an expected decrease in influenza transmission in February-March [6], however, the decrease in 2019/20 is statistically significantly faster than previous years. The second limitation is the interpolation of daily incidence rates of influenza from the weekly data. The daily variation in influenza transmissibility might have been reduced because of this interpolation. The use of daily data of influenza, if available, would address this limitation.

In conclusions, this study found a marked decline in seasonal influenza activity in China during the COVID-19 pandemic. The results suggest that NPIs used against COVID-19 can have collateral benefit on seasonal influenza activity. (1322 words)

Potential conflicts of interest

The authors declare no conflict of interest.

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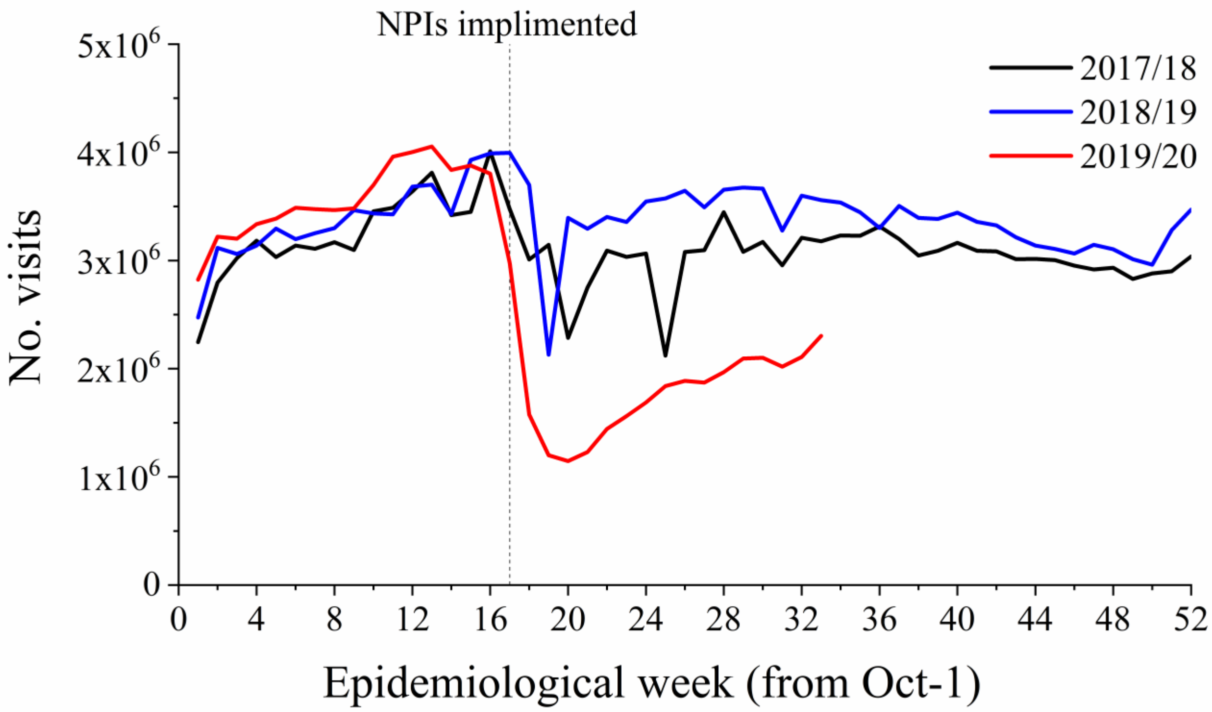
Figure Legend

Figure 1. Seasonal influenza activity during the epidemiological year 2019/20 (red) compared with the epidemiological year 2017/18 (black) and 2018/19 (blue). (A) Average number of visits per week to sentinel hospitals. (B) Number of samples tested from patients with ILI per week. (C) ILI rate among the visiting patients (D) Influenza positivity.

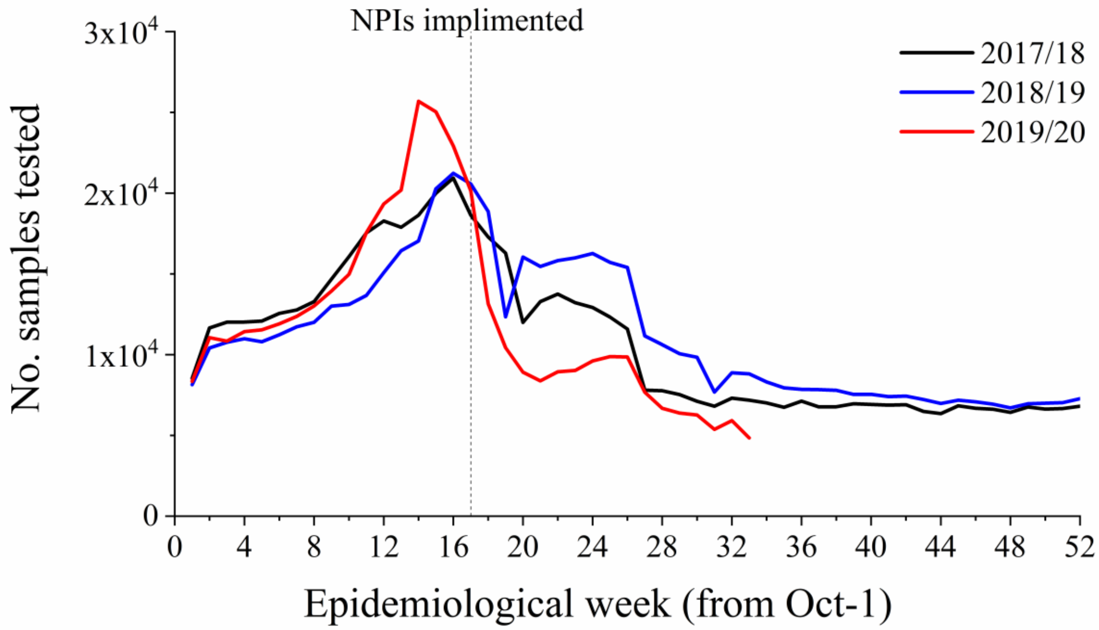
Figure 2. (A) Incidence rate and (B) Daily effective reproductive number of seasonal influenza in the epidemiological year 2019/20 (red) compared with that in 2017/18 (black) and 2018/19 (blue).

Figure-1A



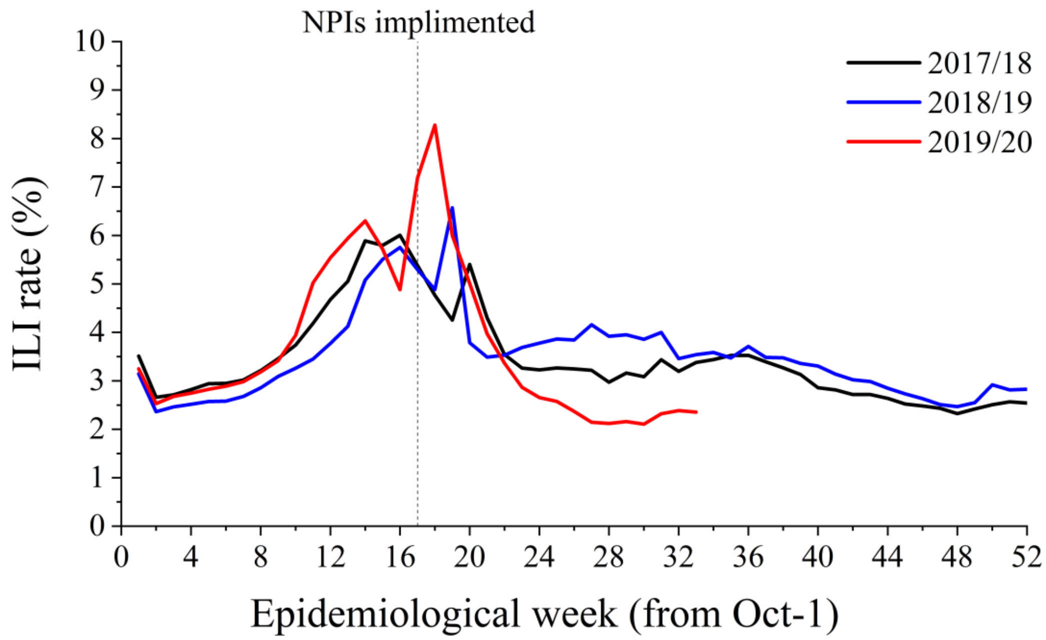
NPIs implimented
5x10^6
4x10^6
3x10^6
2x10^6
1x10^6
0
No. visits
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Epidemiological week (from Oct-1)
2017/18
2018/19
2019/20

Figure-1B



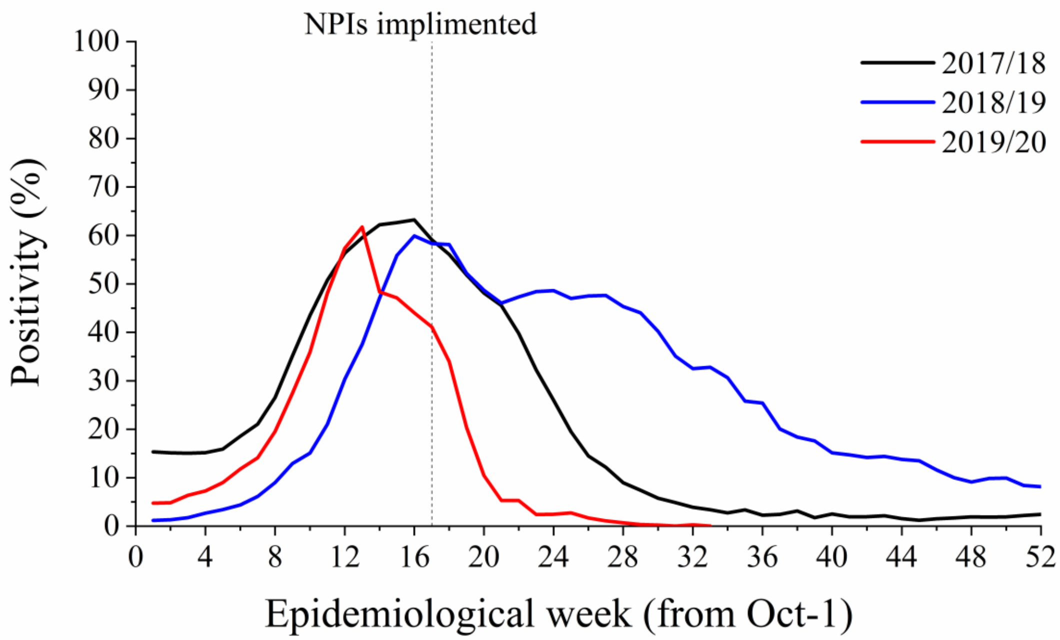
NPIs implimented
2017/18
2018/19
2019/20
3x10^4
2x10^4
1x10^4
0
No. samples tested
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Epidemiological week (from Oct-1)

Figure-1C



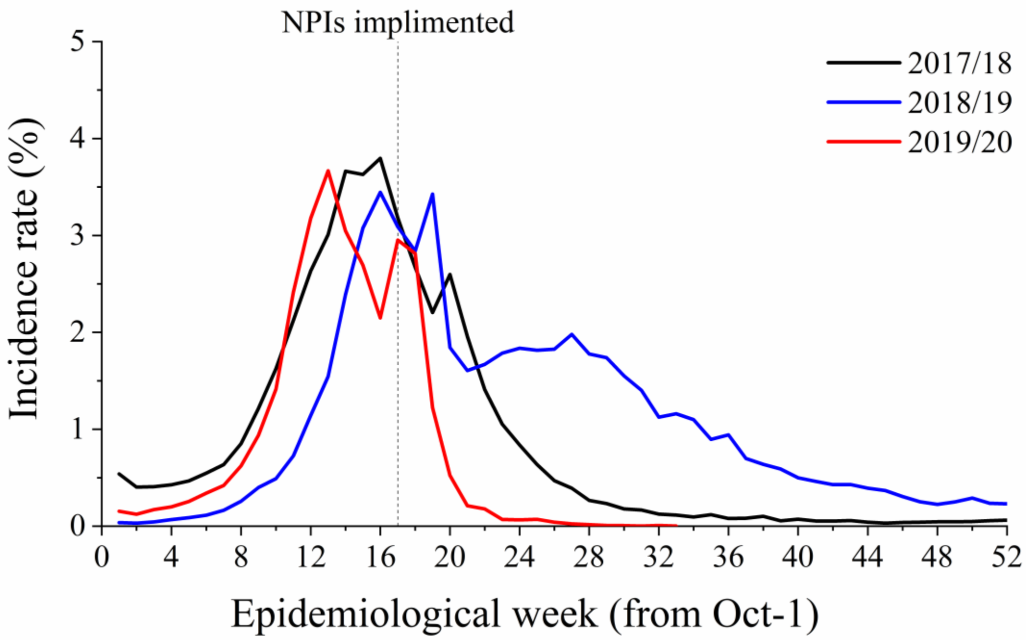
NPIs implimented
2017/18
2018/19
2019/20
ILI rate (%)
Epidemiological week (from Oct-1)
0
1
2
3
4
5
6
7
8
9
10
0
4
8
12
16
20
24
28
32
36
40
44
48
52

Figure-1D



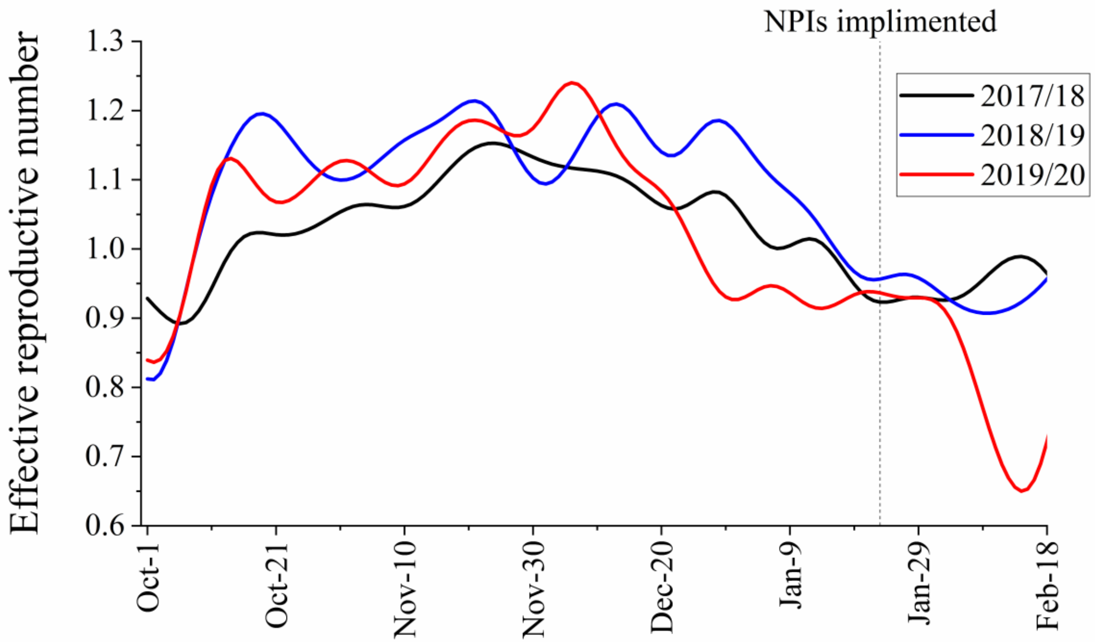
NPIs implimented
2017/18
2018/19
2019/20
Positivity (%)
100
90
80
70
60
50
40
30
20
10
0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Epidemiological week (from Oct-1)

Figure-2A



NPIs implimented
2017/18
2018/19
2019/20
Incidence rate (%)
0
1
2
3
4
5
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Epidemiological week (from Oct-1)

Figure-2B


NPIs implimented
Effective reproductive number
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Oct-1
Oct-21
Nov-10
Nov-30
Dec-20
Jan-9
Jan-29
Feb-18
2017/18
2018/19
2019/20