Persistence and variation of the indirect effects of COVID-19 restrictions on the spectrum of notifiable infectious diseases in China: analysis of national surveillance among children and adolescents from 2018 to 2021

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Abstract

Background: Beyond the direct effect of COVID-19 infection in young people, the wider impact of the pandemic on other infectious diseases is unknown.

Objective: This study aimed to assess changes in the incidence and mortality of 42 notifiable infectious diseases during the pandemic among children and adolescents in China, compared to pre-pandemic levels.

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Results: A total of 4,898,260 incident cases and 3,701 deaths were included. The overall incidence of notifiable infectious diseases decreased sharply during the first year of the COVID-19 pandemic (2020) compared to pre-pandemic levels (2018, 2019), and then rebounded in 2021, particularly in South China. Across the past four years, the number of deaths steadily decreased. The incidence of diseases rebounded differentially by pandemic phase. For instance, although seasonal influenza dominated respiratory diseases in 2019, it showed a substantial decline during the pandemic (% change in phase ? 2020: 0.21 95%CI[0.09-0.50]), which persisted until 2021 (% change in phase IV 2021: 1.02 95%CI[0.74-1.41]). The incidence of gastrointestinal and enterovirus diseases decreased by 33.6% during 2020, but rebounded by 56.9% in 2021, mainly driven by hand-foot-mouth disease (% change in phase ? 2021: 1.28 95%CI[1.17-1.41]) and infectious diarrhea (% change in phase ? 2020: 1.22 95%CI[1.17-1.28]). Sexually transmitted and blood-borne diseases were restrained during the first year of 2021 but

rebounded quickly in 2021, mainly driven by syphilis (% change in phase ? 2020: 1.31 95%CI[1.23-1.40]) and gonorrhea (% change in phase ? 2020: 1.10 95%CI[1.05-1.16]). Zoonotic diseases were not dampened by the pandemic but continued to increase across the study period, mainly due to brucellosis (% change in phase ? 2020: 0.94 95%CI[0.75-1.16]). Vectorborne diseases showed a significant continuous decline during 2020, dominated by hemorrhagic fever (% change in phase ? 2020: 0.68 95%CI[0.53-0.87]), but rebounded in 2021.

Conclusions: The COVID-19 pandemic was associated with a marked decline in notifiable infectious diseases in Chinese children and adolescents. These effects were not sustained, with evidence of a rebound to pre-pandemic levels by late 2021. Maintaining disease surveillance and strengthening implementation of initiatives such as extended immunization programs, stronger prioritization of sexually transmitted infections, maintaining implementable of non-pharmaceutical intervention projects, and managing imported infections will be necessary to respond to the post-pandemic rebound in overall infectious diseases in children and adolescents.

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Contributors: LC, LW and YX conceptualized and designed the study, completed the statistical analyses, drafted the initial manuscript, and reviewed and revised the manuscript. Prof. YD, JM and YS contributed to the conceptualization and design of the study, supervised the data collection, the statistical analyses and initial drafting of the manuscript, and reviewed and revised the manuscript. Prof. S.M.S and J.M contributed to interpretation of the data, and critically reviewed and revised the manuscript from preliminary draft to submission. Dr. JX, BS, MG, XR, YZ, JL, TM, and MC assisted with the data interpretation, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Data sharing: All of the data (de-identified) collected in the surveillance system can be shared with investigators whose proposed use of the data has been approved by an independent review committee identified for this purpose by contacting the corresponding author. The study protocol and statistical analysis plan must be approved by the committee. Proposals should be directed to dongyanhui@bjmu.edu.cn, songyi@bjmu.edu.cn, or majunt@bjmu.edu.cn.

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Keywords: children and adolescents; COVID-19; notifiable infectious diseases

Introduction

Globally, the nearly 1.9 billion children and adolescents under the age of 20 who account for approximately 26% of the world's population are particularly vulnerable to infectious diseases [1, 2]. Yet previous research has suggested that compared to adults, children and adolescents are more likely to be asymptomatic or have milder symptoms of COVID-19, experience a shorter course of illness, and have a lower risk of developing severe disease[4, 5]. They are also less likely to suffer from multi-system inflammatory syndrome (MIS-C)[6]. In China, there has been relatively limited epidemiological research on COVID-19 infections among children and adolescents and the bulk of studies have focused on the original virus strains from the early stages of the outbreak. For instance, the largest published Chinese population study to date included only 2,135 children and adolescents infected with COVID-19 from January to February 2020 [3]. As COVID-19 related restrictions lifted around the world, the number of children and adolescents infected with the virus has risen sharply [4, 5].

In the early response to the COVID-19 pandemic, countries variably introduced a series of social and behavioural measures (e.g. border closures, quarantine, lockdowns, school closures, travel restrictions, face masks) to reduce viral transmission. These approaches have been shown to be relatively effective [6-11]. For example, short-term prospective observational research has indicated that school closures and restricted social distancing were associated with a 38% reduction in the incidence of COVID-19 [12]. Another study conducted in 11 countries demonstrated a 15% reduction in the incidence of COVID-19 associated with multiple social restrictions, and that earlier implementation of lockdown was associated with a larger reduction in the incidence of COVID-19.[13] Social restrictions aimed at limiting the transmission of COVID-19 have also had an indirect effect on the incidence of a wide range of other infectious diseases, thought to reflect interruption of the transmission chain [14]. Respiratory diseases have been particularly affected [14-17]. Chinese surveillance has shown that test-positive rates of all respiratory viruses decreased in the early phases of the COVID-19 pandemic during 2020, with reductions that ranged from 17.2% for respiratory syncytial virus to 87.6% for influenza virus.[16] These patterns were also evident in countries with low prevalence of COVID-19, such as Australia, which experienced a 36% reduction in antibiotic dispensing for respiratory tract infections in the first year of the pandemic[18]. In England, in the first 12 months after the onset of the COVID-19 pandemic, large and sustained reductions were found in the rates of hospital admissions for respiratory infections as well as for a spectrum of other severe and vaccine-preventable childhood infections, such as meningitis [16].

In any country, it is apparent that a balance of factors has affected the transmission and severity of COVID-19, including the timing and intensity of lockdowns and their subsequent lightening, evolving virus strains, and access to vaccines. What is less clear is how these dynamic changes have impacted other infectious diseases. For instance in China, hand-foot-mouth disease surged following the gradual lightening of COVID-19 restrictions, distinct to scarlet fever or seasonal influenza which remained at lower levels [19]. Although several studies have investigated the impacts of COVID-19 related restrictions early in the pandemic, there has been less attention to children and adolescents. Indeed, there has been no systematic exploration in children and adolescents of the effects of the COVID-19 pandemic and associated social restrictions on the spectrum of infectious diseases or in the context of the lifting of these restrictions[15-17, 19]. The present study analysed data for 42 notifiable infectious diseases in children and adolescents in mainland China from 2018 to 2021 to investigate the indirect effect of COVID-19 restrictions on a wide spectrum of infectious diseases. Specifically, we aimed to determine the variability and persistence of this indirect effect across age, sex, time, region, and disease category, with expectation that this information can inform the nature of protective strategies for children and adolescents within subsequent pandemics

Methods

Data collection

Using the China Information System for Disease Control and Prevention (CISDCP), we identified data on daily new cases and deaths for 42 notifiable infectious diseases reported in children and adolescents aged 5-22 years old between 2018 and 2021. For each case, we recorded the date and location of disease onset and death, diagnosed disease, age, and sex. The CISDCP covers 55,077 national health facilities in 397 cities across all 31 provinces of mainland China, and maintains a detailed surveillance protocol[20]. The CISDCP had a national average coverage rate that remained stable and exceeded 95% for all health facilities at or above the county level during the study period and in 2017, web-based reporting was available for 87.2% of national health facilities[20]. In this analysis we only included children and adolescents with a confirmed diagnosis of any of the 42 notifiable infectious diseases. Cases from Hong Kong and Macao were excluded. Demographic information at the city level was provided by the National Bureau of Statistics of

China[21].

Classification

In this study, we focused on 42 notifiable infectious diseases that are captured within the CISDCP. To classify these diseases, we revised our previous approach to categorization[20], classifying vaccine-preventable infectious diseases and bacterial infections based on their respective modes of transmission. These 42 infectious diseases were grouped into five categories: (1) respiratory diseases, (2) gastrointestinal and enterovirus diseases, (3) sexually transmitted and bloodborne diseases, (4) zoonotic diseases, and (5) vectorborne diseases. Respiratory diseases included 11 diseases: seasonal influenza, mumps, tuberculosis, scarlet fever, rubella, pertussis, measles, meningococcal meningitis, leprosy, and diphtheria. Gastrointestinal and enterovirus diseases included eight diseases: hand-foot-mouth disease (HFMD), infectious diarrhea, dysentery (amoebic dysentery and bacterial dysentery), acute hemorrhagic conjunctivitis, typhoid and paratyphoid, hepatitis A, cholera, and poliomyelitis. Sexually transmitted and bloodborne diseases included six diseases: syphilis, gonorrhea, HIV/AIDS, hepatitis B, hepatitis C, and hepatitis D. Vectorborne diseases include nine diseases: hemorrhagic fever, dengue, Japanese encephalitis, typhus, malaria, kala-azar, schistosomiasis, filariasis, and plague. Zoonotic diseases included 10 diseases: brucellosis, hepatitis E, hydatid disease, rabies, anthrax, leptospirosis, H5N1, H7N9, H1N1, and severe acute respiratory syndrome (SARS).

Epidemic stages and phases

As shown in Figure 1, we divided the four-year study period into three stages of the COVID-19 pandemic based on the timing of the major restrictions that were implemented in response to the pandemic[19]: 2018 and 2019 were considered pre-COVID-19 pandemic years, 2020 was categorized as COVID-year 1 and 2021 as COVID-year 2.

Due to the different intensity of COVID-19 related restrictive measures taken to prevent and control COVID-19, we further divided 2020 into four phases: phase I (Jan 1-Jan 22), phase II (Jan 23- Apr 7), phase III (Apr 8-Aug 31), and phase IV (Sep 1-Dec 31). In phase I, COVID-19 had just broken out and no specific interventions or COVID-19 related restrictions were implemented in mainland China. In phase II, the most intense COVID-19 restrictions were implemented, including school closures and travel restrictions, routine temperature monitoring, mask wearing and social distancing, and isolation for those with COVID-19 and high-risks group. In phase Ⅲ, marked by the lifting of the lockdown of Wuhan (Apr 8, 2020), all provinces of mainland China downgraded their response to the public health emergency, and there was a return to regular education, work, and public transit in cities without major COVID-19 outbreaks. During this phase, a variety of COVID-19 related restrictions remained in practice, including social distancing, mask wearing, routine temperature monitoring, school closures and capping the number of meetings. Phase IV began on Sep 1, signaling the return of businesses, recreational activities, and school reopenings across the nation. However, routine temperature monitoring and mask wearing were still widely practiced. In order to mitigate the influence of seasonal characteristics on infectious diseases, we applied these same four phases, identified in 2020, to each of the study years, which resulted in each year, from 2018 to 2021 being divided into four phases. During all epidemic phases in 2021, routine temperature monitoring and mask wearing were still practiced, as described in figure 1. In China, widespread vaccination against COVID-19 began in 2021.

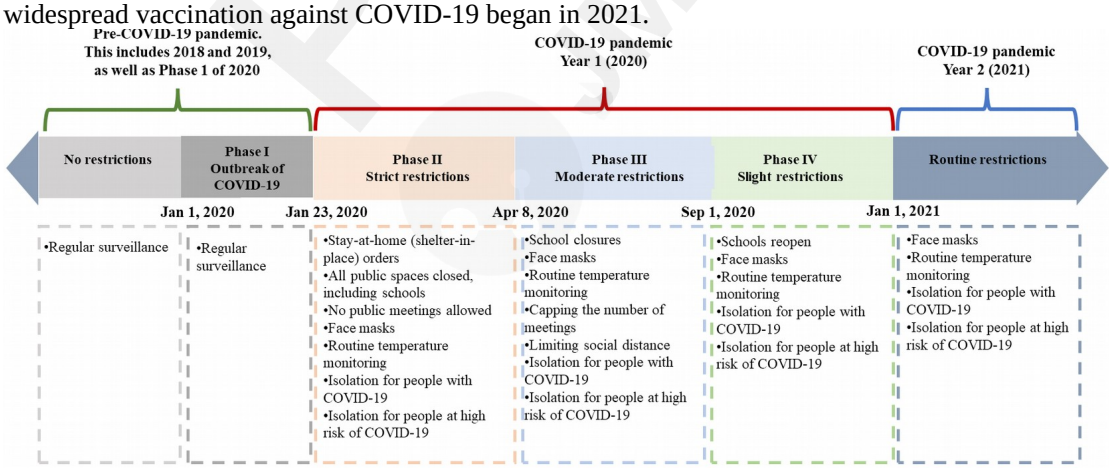

Figure 1. Categorization of the three stages (pre-COVID-19 [2018, 2019], Year 1 [2020] and Year 2 [2021] of the pandemic) and four phases of the first year of the pandemic in China (2020), by intensity of COVID-19 restrictions.

Statistical analysis

Incidence and mortality were used to present trends by year from 2018 to 2021. Incidence (per 100,000) was calculated by the number of incident cases divided by the number of the population aged 5-22. Mortality (per 100,000) was calculated by the number of deaths divided by the number of the population aged 5-22 (per 100,000).To assess changes in the four epidemic phases, the percent change (PC) for "during vs. pre" was calculated by the formula: $\frac{[incidence(2020)-incidence(2018-2019)]}{incidence(2018-2019)}\times 100\%$ and the PC for "COVID-year 1 vs. COVID-year 2" was assessed by the following formula: $\frac{[incidence(2021)-incidence(2020)]}{incidence(2020)}\times 100\%$. Heat maps were used to show the characteristics of each disease for incidence, number of cases, and number of deaths. Stacked plots were used to visualize the proportion of each infectious disease. To illustrate the trends in infectious diseases from 2018 to 2021, the spiral visualization was used to represent the daily number of incident cases.

To assess the changes in the epidemic phases, PC in incidence of each category was calculated at the city level: $\frac{[incidence(phase\,x\in 2020-2021)-incidence(phase\,x\in 2018-2019)]}{incidence(phase\,x\in 2018-2019)}\times 100\%$ where $incidence(phase\,x\in 2020-2021)$ indicated the average incidence in the corresponding phase in 2021 or 2020 and $incidence(phase\,x\in 2018-2019)$ indicated the average incidence in the specific phase during 2018-2019. The PC in specific phases was calculated by disease, disease category, year, and prefecture-level city. In order to eliminate the impact of season and quantify the impact of different COVID-19 related restrictions in the epidemic phases on the incidence of infectious diseases, multivariable generalized linear models (GLM) were applied and used to compare changes in regional variation and specific categories of infectious disease changes by epidemic phases in pandemic years compared to the pre-COVID-19 years of the pandemic in 2018 and 2019. A quasi-Poisson model was fitted for prediction using the indicators as follows: phase category for 2020 and 2021, number of person-days (population size times the number of days in the month) as offset. All models were fitted for daily number of cases. Incidence rate ratios (IRR) associated with the phase indicators estimated reflect the effects of COVID-19 restrictions on the incidence of each notifiable disease in the pandemic years. IRRs associated with the diseases categories were also estimated to assess the impact of COVID-19 related restrictions on various diseases categories. All statistical analyses were performed using the R program (Version 4.1.1).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The authors from Peking University had full access to the data in the study.

Results

Changes in the incidence and mortality of notifable infectious diseases, 2018-21

Between 2018 and 2021, nearly five million Chinese children and adolescents between the ages of 5 and 22 (2,818, 718 males, 2,079,542 females) were diagnosed with one of 42 notifiable infectious diseases. There were 3,701 deaths reported during this period (2,530 males, 1,171 females). As depicted in Figure 2, the number of reported cases of notifiable infectious diseases fluctuated throughout the study period. In 2018, 911,522 cases were reported, rising to 2,268,809 in 2019, and declining to 813,635 in 2020, before increasing to 904,294 in 2021. From 2018 to 2020, the overall incidence of notifiable infectious diseases was 248.848, 738.338, 266.051, and 281.664 per 100,000, respectively by year. During the first year of the COVID-19 pandemic in 2020, the incidence of notifiable infectious diseases dropped significantly by 46.1% but rebounded by 5.9% in 2021. Nevertheless, the total mortality and number of deaths decreased steadily over the four year period, with rates of 0.304 (1112 cases), 0.340 (1045 cases), 0.286 (869 cases), and 0.210 (675 cases) per 100,000 over each year, respectively (Appendix 1 and 22).

Table 1. Incidence (per100,000) and mortality (per 100,000) for 42 notifiable infectious diseases in 5-22 year olds, by year.

Disease classification	2018		2019		2020		2021		Percent change, %	
	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	During- vs. pre-	COVID year 1 vs. 2
Total	248.847	0.304	738.338	0.340	266.051	0.286	281.664	0.210	-46.1	5.9
Respiratory diseases (SI included)	135.956	0.019	600.910	0.026	170.913	0.017	150.056	0.008	-53.6	-12.2
Respiratory diseases (SI excluded)	83.100	0.016	120.369	0.019	50.768	0.011	43.241	0.007	-50.1	-14.8
SI	52.858	0.003	480.541	0.007	120.145	0.006	106.815	0.001	-55.0	-11.1
Mumps	47.578	-	68.429	-	21.947	<0.001	18.071	-	-62.2	-17.7
TB	23.769	0.016	29.085	0.018	25.597	0.010	19.969	0.007	-3.1	-22.0
SF	10.586	-	13.606	-	2.572	-	4.266	-	-78.7	65.9
Rubella	0.633	-	8.296	-	0.458	-	0.093	-	-89.7	-79.7
Pertussis	0.371	-	0.697	-	0.137	-	0.804	-	-74.3	486.9
Measles	0.142	-	0.227	-	0.039	-	0.018	-	-78.9	-53.8
MM	0.011	<0.001	0.017	0.001	0.007	0.001	0.011	<0.001	-50.0	57.1
Leprosy	0.010	-	0.012	-	0.011	-	0.009	-	0.0	-18.2
Diphtheria	-	-	-	-	-	-	-	-	-	-
Gastrointestinal and enterovirus	79.556	<0.001	96.056	0.001	58.341	0.001	91.529	-	-33.6	56.9
HFMD	42.638	-	47.122	0.001	13.038	-	36.875	-	-70.9	182.8
ID	30.801	-	41.484	<0.001	40.858	<0.001	50.615	-	13.0	23.9
Dysentery	3.217	<0.001	3.806	-	2.613	-	2.438	-	-25.6	-6.7
AHC	2.010	-	2.694	-	1.229	-	1.110	-	-47.7	-9.7
T/P	0.551	-	0.605	-	0.415	<0.001	0.367	-	-28.2	-11.6

Hepatitis A	0.338	-	0.344	-	0.187	-	0.124	-	-45.2	-33.7
Cholera	0.001	-	<0.001	-	0.001	-	<0.001	-	-	-
Poliomyelitis	-	-	-	-	-	-	-	-	-	-
Sexually transmitted and bloodborne	32.133	0.268	39.336	0.304	35.562	0.259	38.753	0.197	-0.5	9.0
Hepatitis B	11.900	0.001	12.626	0.001	9.800	0.003	9.200	0.001	-20.1	-6.1
Syphilis	9.133	-	12.659	-	13.335	-	15.916	0.001	22.4	19.4
Gonorrhoea	7.351	-	9.877	-	8.935	-	10.233	-	3.7	14.5
HIV/AIDS	3.099	0.267	3.492	0.303	2.964	0.256	2.942	0.196	-10.1	-0.7
Hepatitis C	0.647	<0.001	0.678	-	0.525	<0.001	0.459	-	-20.8	-12.6
Hepatitis D	0.002		0.004	-	0.001	-	0.002	-	-66.7	100.0
Zoonotic	0.660	0.011	0.861	0.007	0.899	0.006	0.982	0.004	18.2	9.2
Brucellosis	0.364	-	0.497	-	0.63	-	0.721	<0.001	46.3	14.4
Hepatitis E	0.144	-	0.186	-	0.117	-	0.131	-	-29.1	12.0
HD	0.132	-	0.158	-	0.138	-	0.117	-	-4.8	-15.2
Rabies	0.011	0.011	0.008	0.007	0.008	0.006	0.003	0.003	-15.8	-62.5
Anthrax	0.007	<0.001	0.008	-	0.003	-	0.007	<0.001	-60.0	133.3
Leptospirosis	0.002	-	0.003	-	0.004	-	0.002	-	60.0	-50.0
H5N1	-	-	-	-	-	-	-	-	-	-
H7N9	-	-	-	-	-	-	-	-	-	-
SARS	-	-	-	-	-	-	-	-	-	-
Vectorborne	0.542	0.005	1.175	0.001	0.335	0.002	0.344	0.001	-61.0	2.7
HF	0.205	0.001	0.169	-	0.179	0.001	0.227	0.001	-4.3	26.8
Dengue	0.167	-	0.854	-	0.039	-	0.001	-	-92.4	-97.4
JE	0.104	0.004	0.052	0.001	0.035	0.001	0.031	<0.001	-55.1	-11.4
Typhus	0.039	-	0.071	-	0.067	-	0.071	-	21.8	6.0

Malaria	0.022	-	0.023	-	0.0100	<0.001	0.0100	-	-55.6	0.0
Kala-azar	0.005	-	0.005	-	0.005	-	0.002	-	0.0	-60.0
SM	<0.001	-	0.001	-	0.001	-	-	-	-	-
Filariasis	-	-	-	-	-	-	-	-	-	-
Plague	-	-	-	-	-	-	-	-	-	-

Note:-, no cases; HFMD, Hand, foot, and mouth disease; ID, Infectious diarrhea; AHC, Acute hemorrhagic conjunctivitis; T/P, Typhoid and paratyphoid; SI, Seasonal influenza; TB, Tuberculosis; SF, Scarlet fever; MM, Meningococcal meningitis; AIDS, HIV/AIDS; HF, Hemorrhagic fever; JE, Japanese encephalitis; SM, Schistosomiasis; HD, Hydatid disease; SARS, severe acute respiratory syndrome.

Trends of notifiable infectious diseases, by category, 2018-21

Table 1 and Figure 3 present the overall and temporal trends across the five categories of infectious diseases, before and during the COVID-19 pandemic. Among the five categories, respiratory, sexually transmitted and bloodborne, and gastrointestinal and enterovirus diseases were the most commonly reported notifiable infectious diseases in 5-22-year-olds (Appendix 33). Although the overall incidence of notifiable infectious diseases in children and adolescents declined during the first year of the COVID-19 pandemic and then increased during COVID-year 2, the different categories of infectious diseases exhibited diverse temporal changes. Generally, the peak of infectious diseases was reached in the period from December 2019 to January 2020, attributed to a seasonal influenza outbreak. The incidence of notifiable infectious diseases in the first year of the COVID-19 pandemic (2020) was higher than in the pre-pandemic years, but then dropped dramatically from February 2020 to March 2021, before rising at the end of the reporting period in the last quarter of 2021 (Figure 4).

The seasonality of respiratory diseases is generally pronounced in winter in China. This was not experienced in the first year of the COVID-19 pandemic, with the 4th quarter of 2020 and the 1st quarter of 2021 having a low incidence of respiratory diseases. This appeared to rebound the following year, with much higher levels in the 4th quarter of 2021. Seasonal influenza dominated these trends; before the pandemic, the incidence of influence in 2019 was eight times more common than in 2018 (incidence rate of 480.541 vs. 52.858, respectively), and stayed higher than 2018 across 2020 and 2021. Excluding seasonal influenza, the incidence of all other respiratory diseases continued to decline during the COVID-19 pandemic (50.768 and 43.241 per 100,000 in 2020 and 2021), compared to pre-COVID-19 levels (average 106.735 per 100,000), especially for mumps, tuberculosis, scarlet fever and rubella. The one exception was pertussis. The leading causes of respiratory deaths were tuberculosis and seasonal influenza. The number of deaths decreased steadily during these four years (Appendix 4).

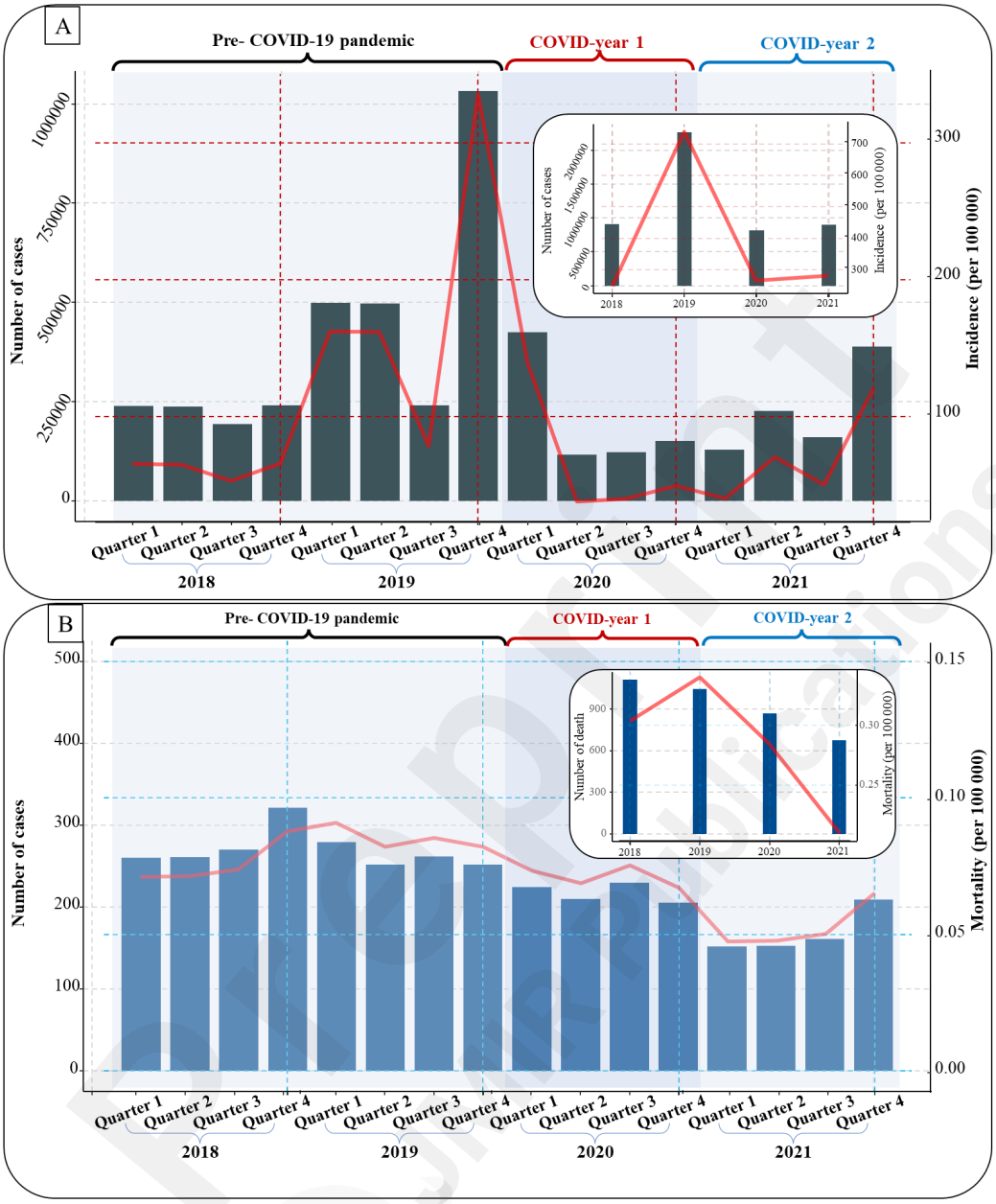

Figure 2. Trends in incidence (Panel A, number of cases and rate) and mortality (Panel B, number of cases and rate) of notifiable infectious diseases in 5-22-year-old Chinese children and adolescents, by year and quarter.

Generally in China, gastrointestinal and enterovirus diseases peak in incidence from April to July. This peak was not experienced during the COVID-19 pandemic in 2020. Compared to the two pre-COVID years, the incidence of gastrointestinal and enterovirus diseases decreased by 33.6% in 2020, but rebounded by 56.9% in 2021. HFMD and infectious diarrhea were the main contributors to this rebound of gastrointestinal and enterovirus diseases. Infectious diarrhea surpassed HFMD as the most common notifiable infectious disease among the gastrointestinal and enterovirus diseases category in 2020.

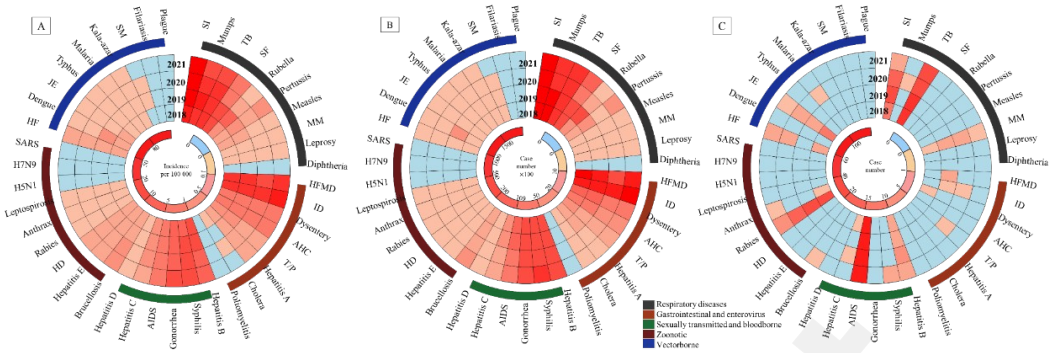

Figure 3. The trends in incidence (A), number of cases (B), and number of deaths (C) for 42 notifiable infectious diseases by disease category, from 2018 to 2021

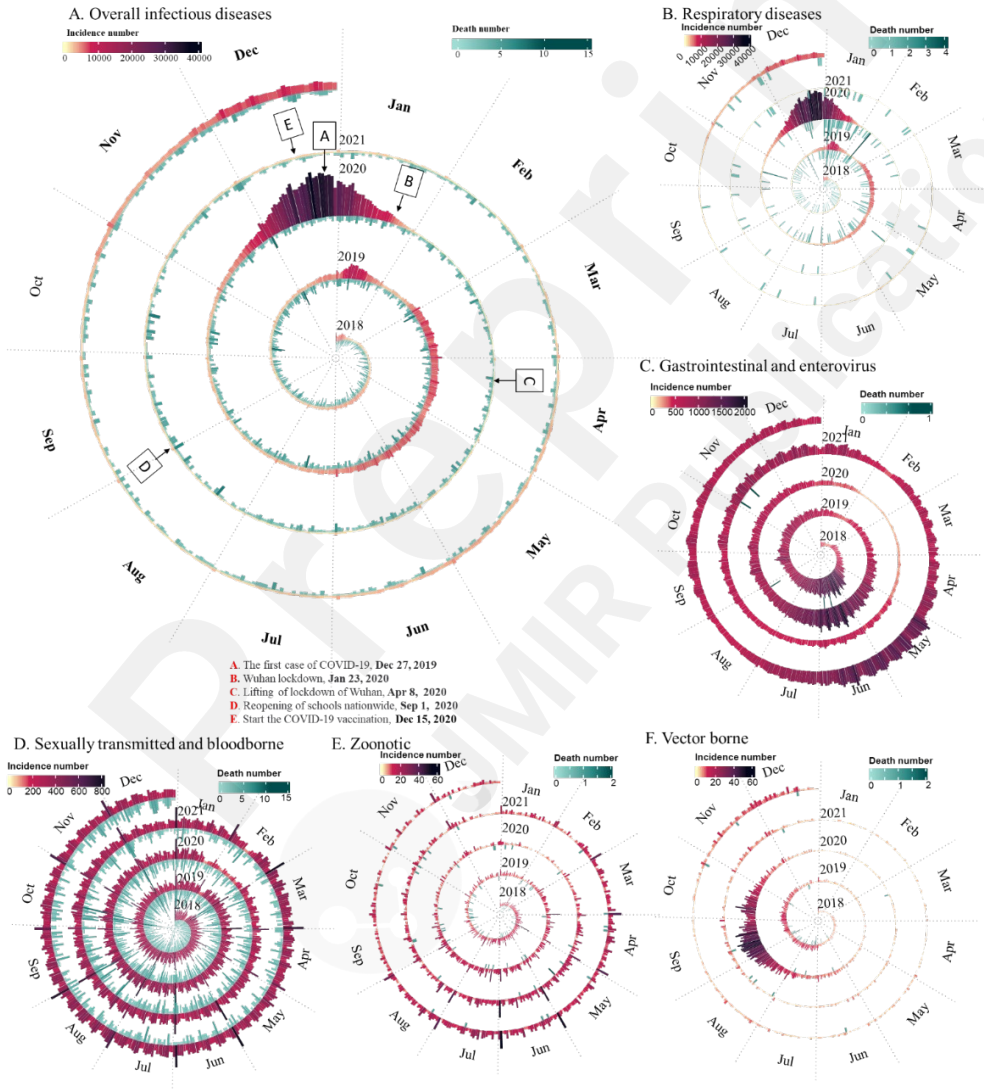

Figure 4. Temporal changes in incidence of infectious diseases by disease category and day, from 2018 and 2019 (pre-COVID-19), and year 1 (2020) and year 2 (2021) of the COVID-19 pandemic.

Different trends were apparent in the sexually transmitted and bloodborne diseases category. During the first year of the COVID pandemic, the previous increase in incidence experienced in the

pre-COVID years was curbed (32.133 and 39.336 per 100,000 in 2018 and 2019 vs. 35.562 per 100,000 in 2020), but was then followed by a distinct rebound in the second year of the pandemic (38.753 per 100,000 in 2021), a 9.0% increase from 2020. The incidence of Hepatitis B, C and D, and AIDS/HIV remained stable or declined slightly during-COVID-19 pandemic, but syphilis and gonorrhoea increased significantly in both years of the pandemic. In 2018, the disease with the highest incidence within the sexually transmitted and bloodborne diseases category was hepatitis B. Hepatitis B was overtaken by syphilis from 2019 to 2021, particularly in adolescents aged 15 to 19 years (Figure 5). Across the four years, HIV/AIDS remained the major cause of death from any infectious disease in children and adolescents, although the mortality rate decreased by 26.6% over this period, from 0.267 per 100,000 in 2018 to 0.196 per 100,000 in 2021.

In China, zoonotic diseases typically show a seasonal pattern with the highest incidence in summer. Zoonotic diseases seemed less affected by COVID-19, with the incidence continuing to increase from 0.660 per 100,000 in 2018 to 0.982 per 100,000 in 2021, an increase of 18.2%. While this was mainly attributed to brucellosis, which has the highest incidence among zoonotic diseases, the previous growth trends of other zoonotic diseases such as hepatitis E and hydatid disease were also constrained. The incidence and mortality of rabies continued to decline during the study period, although it remained the 3rd leading cause of death from any notifiable infectious disease in children and adolescents in China (followed by HIV/AIDS and tuberculosis).

There was a substantial pre-pandemic increase in the incidence of vectorborne disease from 2018 to 2019 (from 0.542 to 1.175 per 100,000 in 2018 and 2019, respectively), which remained low during 2020 and 2021. This was accounted for by Dengue, Japanese encephalitis, typhus, malaria and kala-azar which showed marked a declines in 2020 (0.335 per 100,000) which remained low in 2021 (0.344 per 100,000). In contrast, hemorrhagic fever appeared to rebound during the COVID-19 pandemic, increasing by 26.8%.

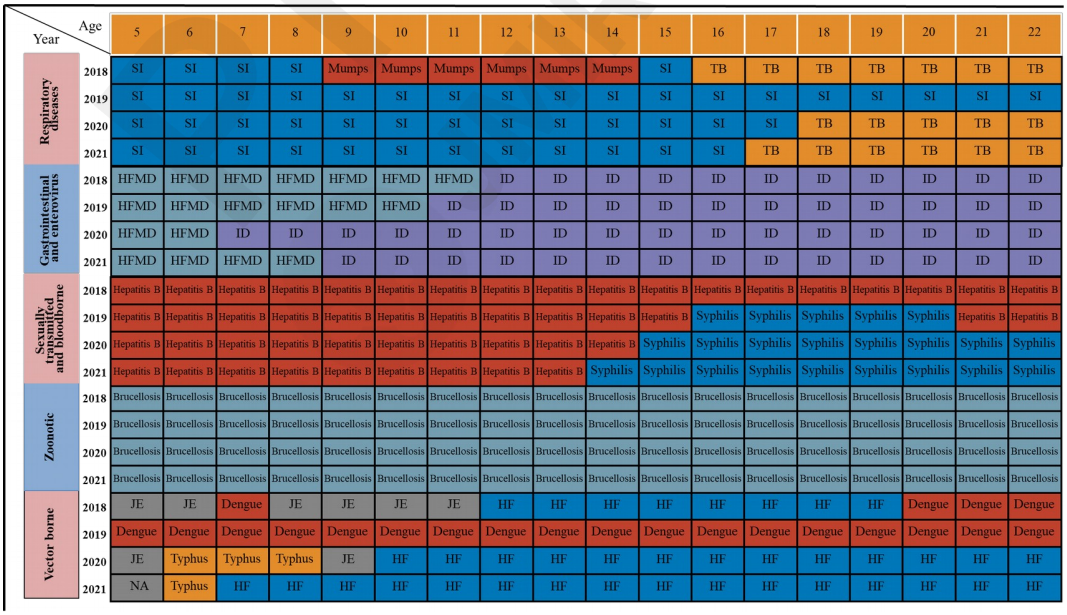

Figure 5. The leading infectious diseases by incidence by disease category and across age, from 2018 to 2021.

Note: HFMD, Hand-foot-mouth disease; ID, Infectious diarrhea; SI, Seasonal influenza; TB, Tuberculosis; HF, Hemorrhagic fever; JE, Japanese encephalitis.

Regional variations in infectious diseases changes by epidemic phase

In the pre-pandemic years, there was evidence of a geographic North-South demarcation (the “Qinling-Huaihe River") which tends to separate China into two regions with differing incidence of notifiable infectious diseases. Compared with North China, South China has a more serious burden of infectious diseases, a pattern which remained evident in 2020 and 2021 (Figure 6 and Appendix 55).

We compared changes in regional variation using the categories in 2018, 2019, and 2021 that were defined by the four phases of the pandemic in 2020. Compared to the same timed phase in 2018 and 2019, the overall incidence of infectious diseases among children and adolescents was higher in each region in phase Ⅰ of 2020. In phase Ⅱ, the overall incidence of infectious diseases among children and adolescents markedly declined across the country, and the incidence of notifiable infectious diseases was lower in almost all regions of China than the same phase in 2018 and 2019 (Appendix 6). This pattern continued to be evident in phase Ⅲ and phase Ⅳ in 2020. However, in 2021, the incidence of infectious diseases among children and adolescents began to markedly recover, with even higher levels than in the pre-pandemic years in some regions. Given the relative scale of the 2019/21 seasonal influenza outbreak, we conducted sensitivity analyses by excluding seasonal influenza, with consistent findings (Appendix 7).

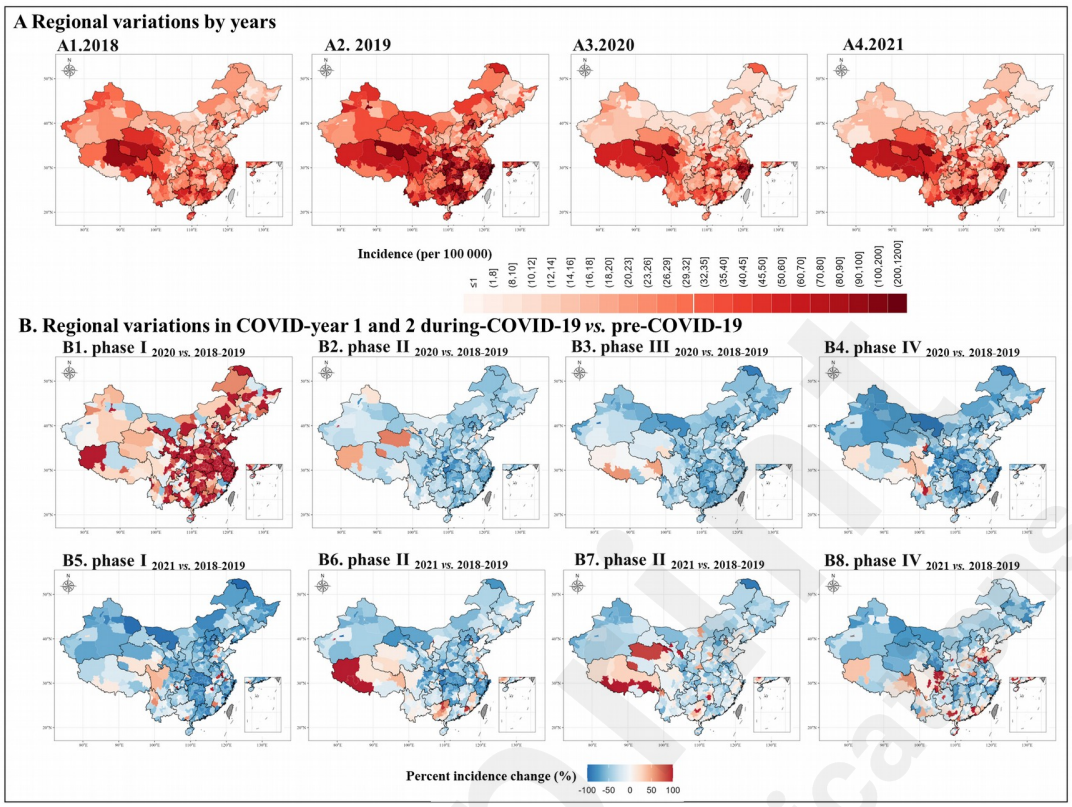

Figure 6. Regional variation in infectious diseases incidence by year (A) and percent change of incidence in each epidemic phase during COVID-year 1 in 2020 and COVID-year 2 in 2021 compared to the average pre-COVID-19 levels for 2018-2019 at city level.

Note: phase I (Jan 1-Jan 22), phase II (Jan 23- Apr 7), phase III (Apr 8-Aug 31), and phase IV (Sep 1-Dec 31).

Persistence and variability of the COVID-19 pandemic by notifiable disease category

As shown in Figure 7 and Appendix 8, an indirect effect of the COVID-19 pandemic was observed on infectious diseases with a sharp decline in overall incidence during the first year of the pandemic in 2020, followed by a resurgence back to pre-COVID-19 pandemic levels for at least some diseases. However, the extent of this differed across the phases by disease category.

Respiratory diseases—The indirect effect of COVID-19 on respiratory diseases among Chinese children and adolescents seemed relatively continuous, as it was accompanied by a lower incidence of each respiratory disease in the two pandemic years when compared with the two pre-pandemic years. There was a rebound in the incidence rate of respiratory diseases, but this only seen in phase IV in 2021, when there was a return to pre pandemic rates. COVID-19 related restrictions appeared to impact the incidence of seasonal influenza, mumps, tuberculosis, scarlet fever, rubella, pertussis, and measles, as their incident IRRs were always lower during the two pandemic years than in the corresponding phases before the COVID-19 pandemic. The overall rebound in the phase IV of 2021 was driven mainly by seasonal influenza, pertussis and meningococcal meningitis with larger IRRs of 1.02 (0.74-

1.41), 2.83 (2.51-3.18) and 1.21 (1.02-1.43) in phase IV of 2021, respectively.

Gastrointestinal and enterovirus diseases—The incidence rebound started from phase III of 2020 and reached a similar level to pre-pandemic years in phase IV of 2020, that was maintained during 2021. The rebound of gastrointestinal and enterovirus diseases was firstly and mainly driven by infectious diarrhea with IRRs in phase II, III, and IV in 2020 of 0.45 (0.41-0.50), 1.22 (1.17-1.28), and 1.48 (1.41-1.55), respectively. There was a similar trend seen in other gastrointestinal and enterovirus diseases which rebounded to various degrees from phase III of 2020, but without recovering to pre-COVID-19 levels in 2018 and 2019.

Sexually transmitted and bloodborne diseases—The indirect effect of COVID-19 on reducing sexually transmitted and bloodborne diseases was not sustained, with a rapid rebound from phase III of 2020 when China ceased its most stringent prevention measures. Following this, their incidence returned to pre-COVID-19 levels. This rapid rebound, particularly in South China, was largely triggered by syphilis and gonorrhea, with an increase of IRRs in phase III of 2020 to 1.31 (1.23-1.40) for syphilis and 1.10 (1.05-1.16) for gonorrhea (Appendix 9-10).

Zoonotic diseases—The indirect effect of COVID-19 on zoonotic diseases seemed week, with a fast rebound after phase III of 2020 and maintaining similar levels to each phase of the pre-COVID-19 years. Brucellosis was the strongest rebound point with a significant IRR of 2.08 (1.86-2.33) in phase III of 2020, particularly in North China.

Vectorborne diseases—The indirect effect of COVID-19 on vectorborne diseases seemed relatively lasting, as incidence during the COVID-19 pandemic years was always lower than the levels before the pandemic. Although hemorrhagic fever and typhus incidence rebounded, this was insufficient to influence the trend for this group of diseases.

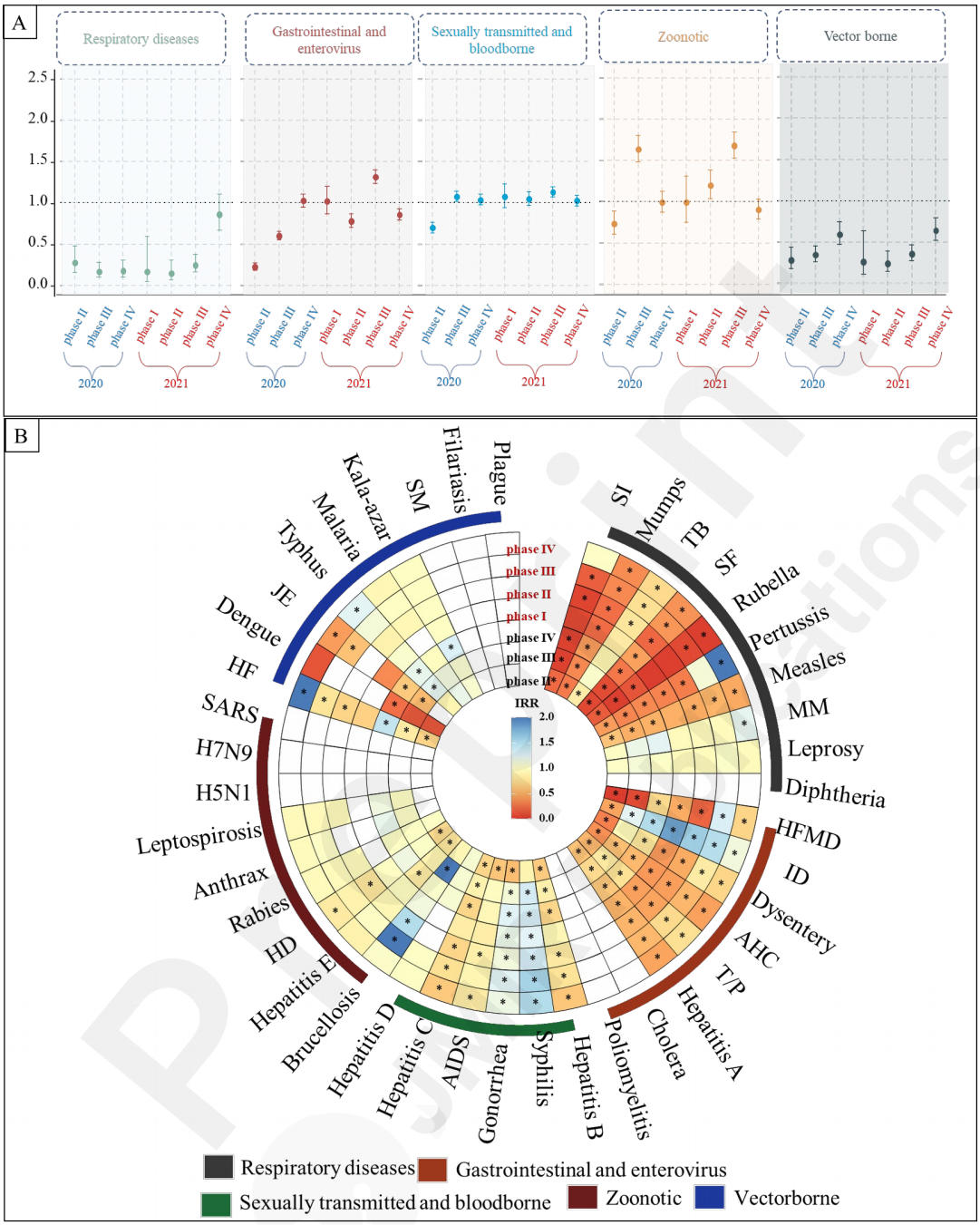

Figure 7. Incidence rate ratio (IRR) in each epidemic phase in 2020 and 2021 for five categories of 42 notifiable infectious diseases.

Discussion

This examination of incidence and mortality of 42 notifiable infectious diseases in Chinese children and adolescents aged 5-22 years in the period immediately before and the two years following the COVID-19 pandemic reveals that initially, the pandemic had a significant indirect effect with marked decreases in all infectious diseases. However, this effect was not sustained, and the incidence of infectious diseases rebounded to previous levels during the second year of the pandemic, particularly in southern China where COVID-19 restrictions were largely lifted by 2021. The indirect effect of the pandemic varied by disease category, region, and time, with sexually transmitted and bloodborne diseases rebounding first, followed by gastrointestinal and enterovirus, and zoonotic diseases. In contrast, the indirect effect of the COVID-19 pandemic appeared to have a more continuous effect on vectorborne and respiratory diseases, with vectorborne diseases remaining below pre-pandemic levels throughout the study period and respiratory diseases only rebounding at the end of the study period.

Comparison with other studies

Numerous studies have shown a reduction in the incidence of infectious diseases during the earliest phases of the COVID-19 pandemic, when strict COVID-19 related restrictions were in place[16, 22-27]. For example, hospital admission data from England showed that various infectious diseases declined during-COVID-19 pandemic, with the largest decline observed in the incidence of seasonal influenza[16]. Other data from China indicated reductions in all infectious diseases, with respiratory diseases having the greatest declines[19, 22, 24]. However Australian research suggested that while various vaccine-preventable infectious diseases declined, the incidence of sexually transmitted and bloodborne diseases increased during the pandemic[26]. We showed that while the incidence of Hepatitis B, C and D, and AIDS/HIV remained stable or declined slightly during the COVID-19 pandemic, syphilis and gonorrhoea increased. The present study adds new evidence that the adoption of national restrictions in response to the COVID-19 pandemic did not consistently or uniformly reduce the incidence of infectious diseases. This reinforces the importance of public health professionals working with governments to formulate comprehensive prevention and control policies for a wider spectrum of infectious diseases beyond simply the focus of pandemic measures. This needs to span from health education to immunization and from individuals to institutions, and must target children and adolescents as well as their parents. A key finding from this study was the substantial geographic disparities in infectious disease distribution observed both before and during the COVID-19 pandemic years. For example, zoonotic diseases predominantly afflicted western regions, whereas vector-borne diseases were largely confined to coastal zones. While mirroring pre-pandemic patterns, such disparities are rooted in economic, geographic, climatic, and social differences, including the effects of urbanization which aggregates populations and potentially heightens the risk of disease transmission [28-35]. The complexity of these regional distribution patterns underscores the value of in-depth research and disease surveillance to help unravel the nuanced relationships between environmental factors and socio-economic determinants of health.

The rebound in respiratory diseases experienced in the last quarter of 2021 was mainly driven by increases in seasonal influenza, pertussis, and meningococcal meningitis. However, these conditions also exhibited the greatest sustained decline in incidence. This signals that the strongest indirect effect of COVID-19 restrictions was in other respiratory infections, which no doubt reflects the impact of socio-behavioural restrictions on respiratory disease transmission[36, 37]. Persisting behavioural restrictions aimed at reducing COVID-19 transmission which remained in place after school reopenings may have contributed to the relative lag seen in returning to pre-COVID levels of seasonal influenza, mumps, scarlet fever, rubella, and measles. The rebound in seasonal influenza, pertussis, and meningococcal meningitis incidence coincided with the peak season for these infectious diseases, which coincided with the lifting of restrictions. During the pandemic, lower incidence of respiratory infectious diseases resulted in low viral exposure and decreased immunization, leading to an "immunity debt" which increases the proportion of people susceptible to infection at the same time as a gradual reduction of herd immunity in the population[38]. Beyond immunization against influenza, pertussis, meningococcal meningitis as well as COVID-19, wearing masks during the peak season for infectious respiratory diseases may be an efficient response to reduce the scale of rebound in respiratory infections, as seen in ongoing efforts in Europe[38].

During the COVID-19 pandemic, there was a significant reduction in the incidence of gastrointestinal and enterovirus diseases in Chinese children and adolescents, which gradually increased as COVID-19 restrictions loosened, eventually returning to average levels. This pattern is consistent with the impact of COVID-19 restrictions on social contact. Consistent with prior research, the greatest decline in gastrointestinal and enterovirus diseases was for HFMD, a seasonal virus that commonly affects children in schools[19, 22, 25]. We showed that infectious diarrhea and dysentery rebounded first, followed by HFMD, but acute hemorrhagic conjunctivitis, typhoid and paratyphoid, and hepatitis A showed persisting lower levels during the monitoring period. Understanding these nuances is important. For example, two rounds of rebound have been described for HFMD, the first coinciding with the reopening of schools, and the second corresponding to the seasonal increases experienced in spring and early summer[39].

During the early phase of the COVID-19 pandemic, the incidence of sexually transmitted and bloodborne diseases declined but rebounded to pre-restriction levels when COVID-19 related restrictions were partially lifted. Gonorrhea and HIV/AIDS rebounded to average levels across 2018 and 2019, but syphilis rebounded to a higher incidence during the second year of the pandemic. Research in the United States[40] and Germany[41] has demonstrated a positive correlation between sexually transmitted diseases and population mobility, suggesting that the COVID-19 restrictions were successful in reducing population movement. Although restrictions on population mobility may have reduced access to sexual partners and high-risk sexual behavior and injecting drug use, the inability to attend hospitals for screening might also have contributed to the reduction of these infections during the pandemic[42]. As restrictions on population mobility were lifted before the reopening of schools, the increase in the incidence of gonorrhea and HIV/AIDS to above historical levels is possibly driven by out-of-school adolescents. Prior research has similarly shown that restrictions put in place to reduce

COVID-19 transmission were not effective in curbing syphilis [43]. In the US, syphilis has been shown to be more prevalent among individuals who had unprotected sex and/or had multiple partners, who were HIV positive and who had sex with peers, with dramatic recent increases in women[44]. One possible reason during the pandemic was the reduced access to condoms, resulting in more unprotected intercourse[45]. These findings suggest that during any pandemic, beyond specific responsive efforts, it is also critical to ensure that programs and interventions to identify and treat sexually transmitted infections are preserved.

Vectorborne diseases, along with respiratory infectious diseases, were the conditions that saw the most benefits from COVID-19 pandemic measures, with incidence levels remaining lower than for longer, despite some rebound in hemorrhagic fever and typhus. The restrictions on population mobility and the rigorous management of students' mobility during the pandemic significantly appear to have decreased the opportunities for children and adolescents to come into contact with vectors and animal reservoirs of vectorborne and zoonotic diseases, resulting in a decreased incidence of both types of infectious diseases, consistent with evidence in adults[19]. While the highly cautious approach by the Chinese government to international travel may have contributed to this, resurgence of vector-borne disease is to be expected once international travel resumes[46], as shown in Italy[47]. International travel has little effect on zoonoses, diseases that appear to be more prevalent in rural areas where children and adolescents have greater interaction with animals and where school closures may increase the risk of exposure to brucellosis for students in rural areas[48].

Implications

Human civilization has experienced numerous pandemics throughout history. Interventions during the COVID-19 pandemic were shown to be powerful in ‘buying time’ for vaccine development and reducing human deaths but there has been far less attention on measures to control the rebound in the incidence of common infectious diseases that tend to recur during the later phases of any epidemic. In developing strategies for responding to future pandemics, beyond direct measures to contain the specific infection, public health policy makers and governments are urged to consider approaches to limiting the expected rebound in the incidence of other infectious diseases, particularly for disease categories where that rebound is higher than pre-pandemic levels. Priority infectious diseases should be selected based on regional monitoring data, and strategies should be developed for all categories of infectious diseases. Interventions in schools may be effective in preventing the rebound of gastrointestinal and enterovirus diseases, while expanding vaccination programs can help make up for the immunization debt caused by limited exposure to respiratory infectious viruses or vaccine shortages during the pandemic. Ensuring that testing and treatment for sexually transmitted diseases remains across any pandemic is important, while developing a response strategy for imported vectorborne illnesses is a priority in any post-pandemic phase.

Strengths and limitations

This study has several notable strengths. Firstly, we used data from the Chinese Information System for

Disease Control and Prevention (CISDCP), which is a long-term, systematic surveillance system that covers over 85% of health facilities in China[20, 49]. In China, much health monitoring occurs in schools, but use of the CISDCP also enabled access to data for out-of-school children and adolescents, which further increased its representativeness. While the CISDCP includes suspected cases, carriers of pathogens, and confirmed cases, we only included patients with diagnoses supported by both uniform clinical standards and laboratory tests, which will have enhanced the accuracy of these results. Several potential limitations should also be noted. The incidence of infectious diseases is influenced by multiple factors during the COVID-19 pandemic, and this study only analyzed the impact of COVID-19 related restrictions, without considering specific meteorological, travel, and human mobility factors. Additionally, the collective nature of COVID-19 related restrictions makes it difficult to assess the effects of individual restrictions. Finally, the variability in COVID-19 policy responses across Chinese provinces in 2021, including fluctuating lockdowns and reopening, and variability in policy reinforcement, complicates the distinction between affected and unaffected areas within these analysis. This variability in policy implementation could potentially lead to an underestimation of the impact of 2021 policies on the incidence rates of infectious diseases.

Conclusions

This study has revealed the indirect impact of COVID-19 related restrictions on the incidence of infectious diseases in 5-22 year old children and adolescents in China. During the COVID-19 pandemic, there was a significant reduction in the incidence of the majority of infectious diseases, particularly respiratory and vectorborne diseases. However, the lifting of national COVID-19 related restrictions resulted in a rapid rebound in gastrointestinal and enterovirus diseases, sexually transmitted and bloodborne diseases, and zoonotic diseases, particularly in the south of China. The overall rebound of infectious diseases was driven by respiratory diseases such as seasonal influenza, pertussis, and meningococcal meningitis, and gastrointestinal and enterovirus diseases such as HFMD and infectious diarrhea. Some sexually transmitted and bloodborne diseases such as syphilis and gonorrhea failed to show any reductions, with persistently rising levels over the pandemic years. Planning for future pandemics needs to appreciate that mitigating strategies for the specific infectious agent, that investment in wider efforts must continue in order to protect children and adolescents. Beyond health education and access to routine immunisations, strategies should include precise approaches for different infectious diseases, strengthening disease surveillance and ensuring access to sexually transmitted infection prevention, diagnosis and treatments.

Multimedia Appendix 1

The trends in number of cases, incidence, number of deaths and mortality rate for 42 notifiable infectious diseases by year and quarter.

Multimedia Appendix 2

The changes in incidence (per100,000) and mortality (per 100,000) for 42 notifiable infectious diseases in China, from 2018 to 2021.

Multimedia Appendix 3

The trends in incidence and proportion for 42 notifiable infectious diseases by disease category, from 2018 to 2021.

Multimedia Appendix 4
Ranking of incidence of each 42 notifiable infectious disease by year, from 2018 to 2021.

Multimedia Appendix 5
The incidence of five categories for 42 notifiable infectious diseases at city level, from 2018 to 2020.

Multimedia Appendix 6
The percent changes of cumulative incidence of five categories for 42 notifiable infectious diseases by epidemic phase at city level

Multimedia Appendix 7
Incidence of overall infectious diseases and percent changes of cumulative incidence in each epidemic phase between 2020, 2021 and the average of 2018−2019 at city level (excluding seasonal influenza).

Multimedia Appendix 8
IRRs for incidence for 42 notifiable infectious diseases in China, from 2018 to 2021.

Multimedia Appendix 9
IRRs for incidence for 42 notifiable infectious diseases in North China, from 2018 to 2021.

Multimedia Appendix 10
IRRs for incidence for 42 notifiable infectious diseases in South China, from 2018 to 2021.

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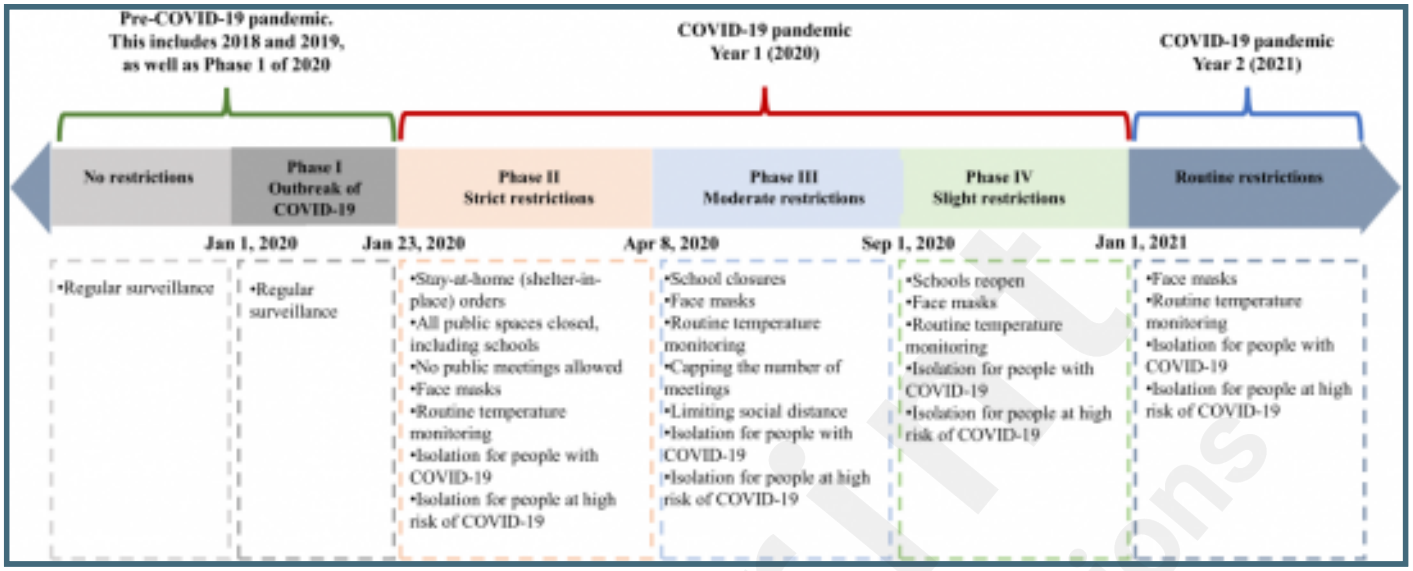
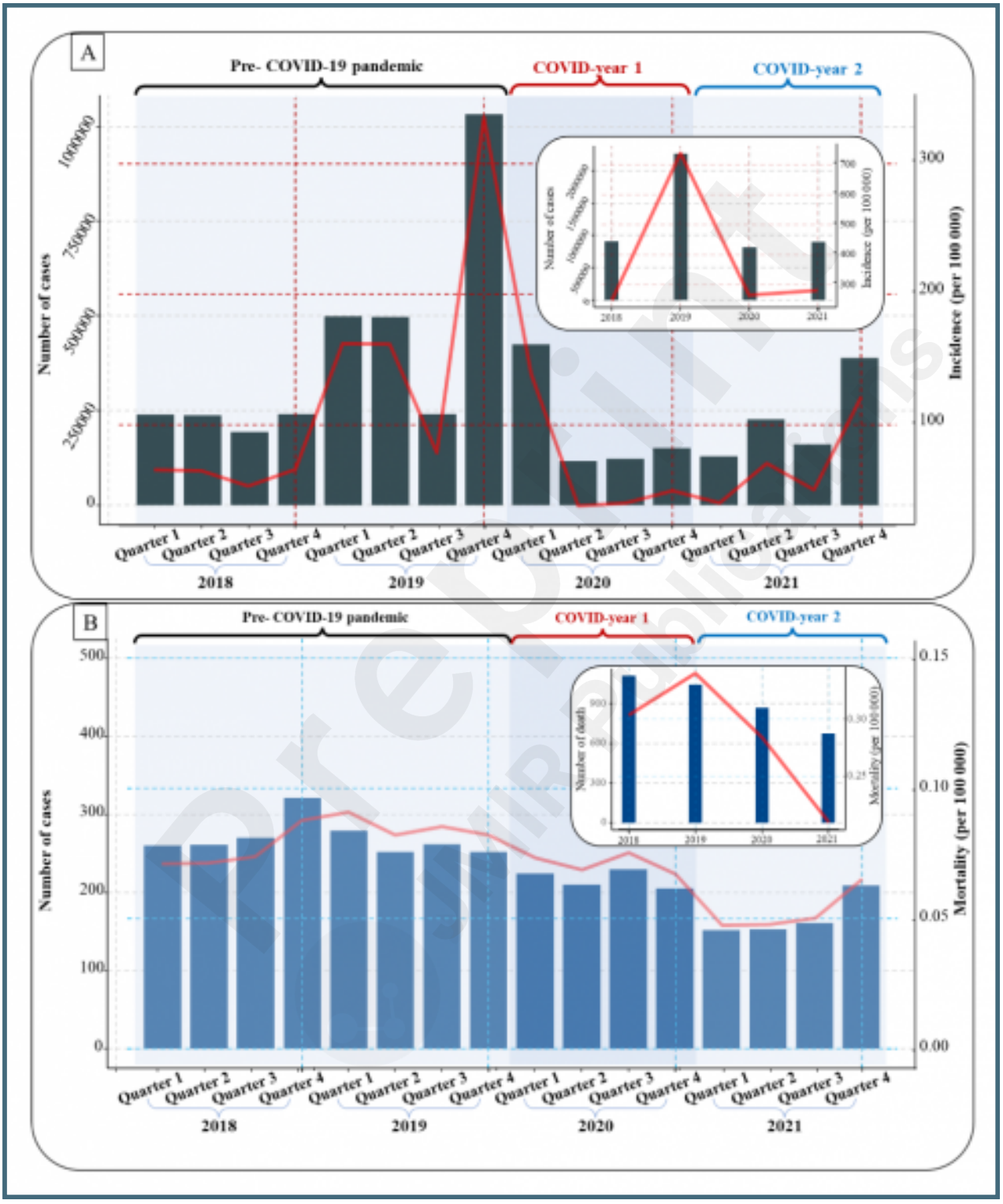
Supplementary Files

Figures

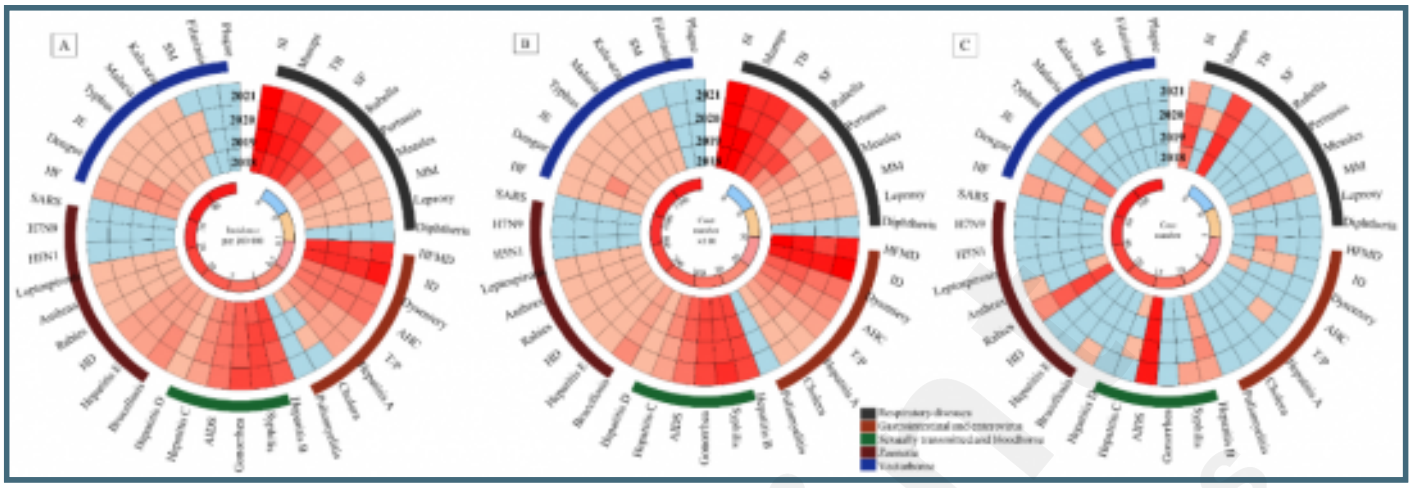
Categorization of the three stages (pre-COVID-19 [2018, 2019], Year 1 [2020] and Year 2 [2021] of the pandemic) and four phases of the first year of the pandemic in China (2020), by intensity of COVID-19 restrictions.



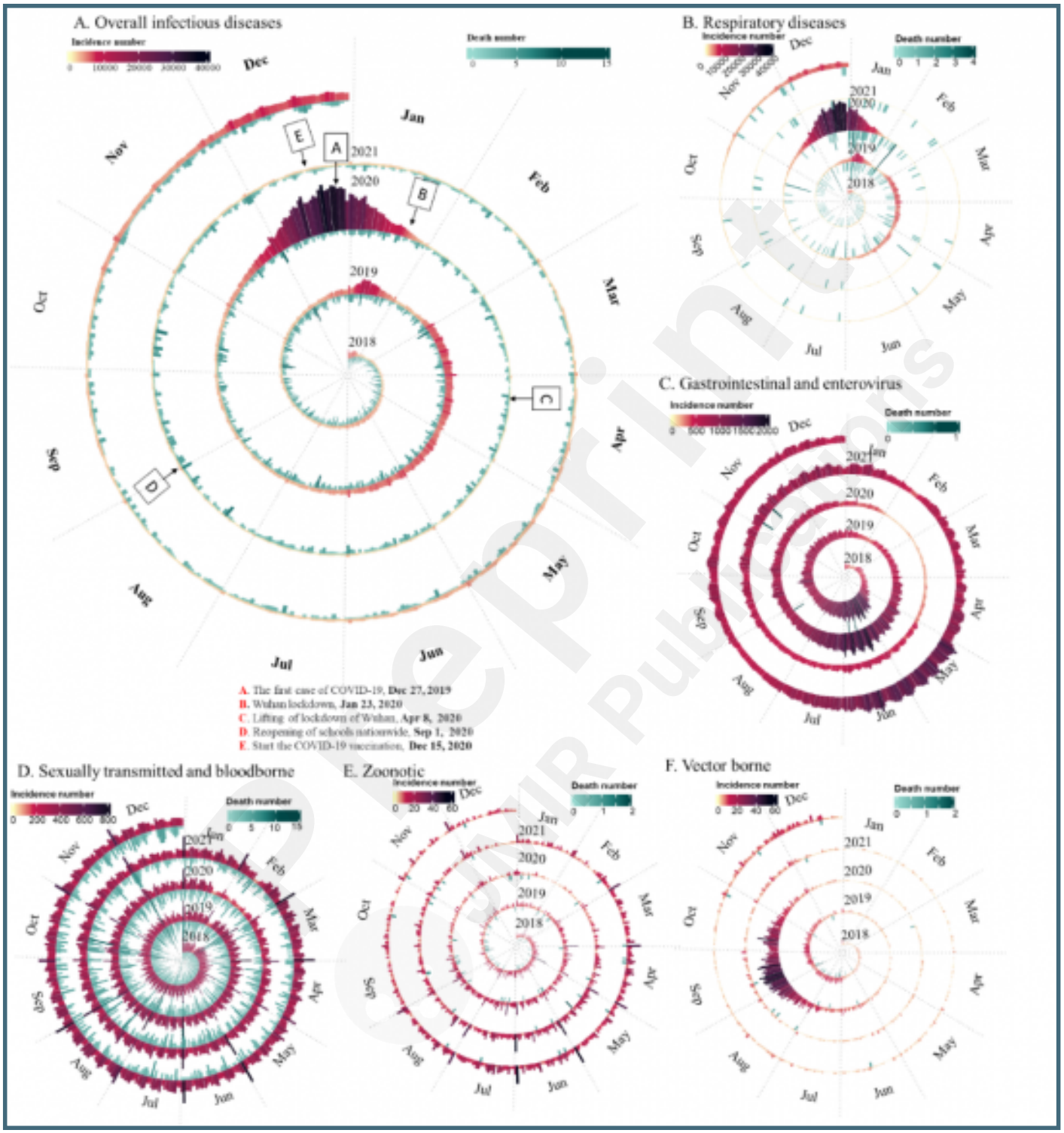
Trends in incidence (Panel A, number of cases and rate) and mortality (Panel B, number of cases and rate) of notifiable infectious diseases in 5-22-year-old Chinese children and adolescents, by year and quarter.



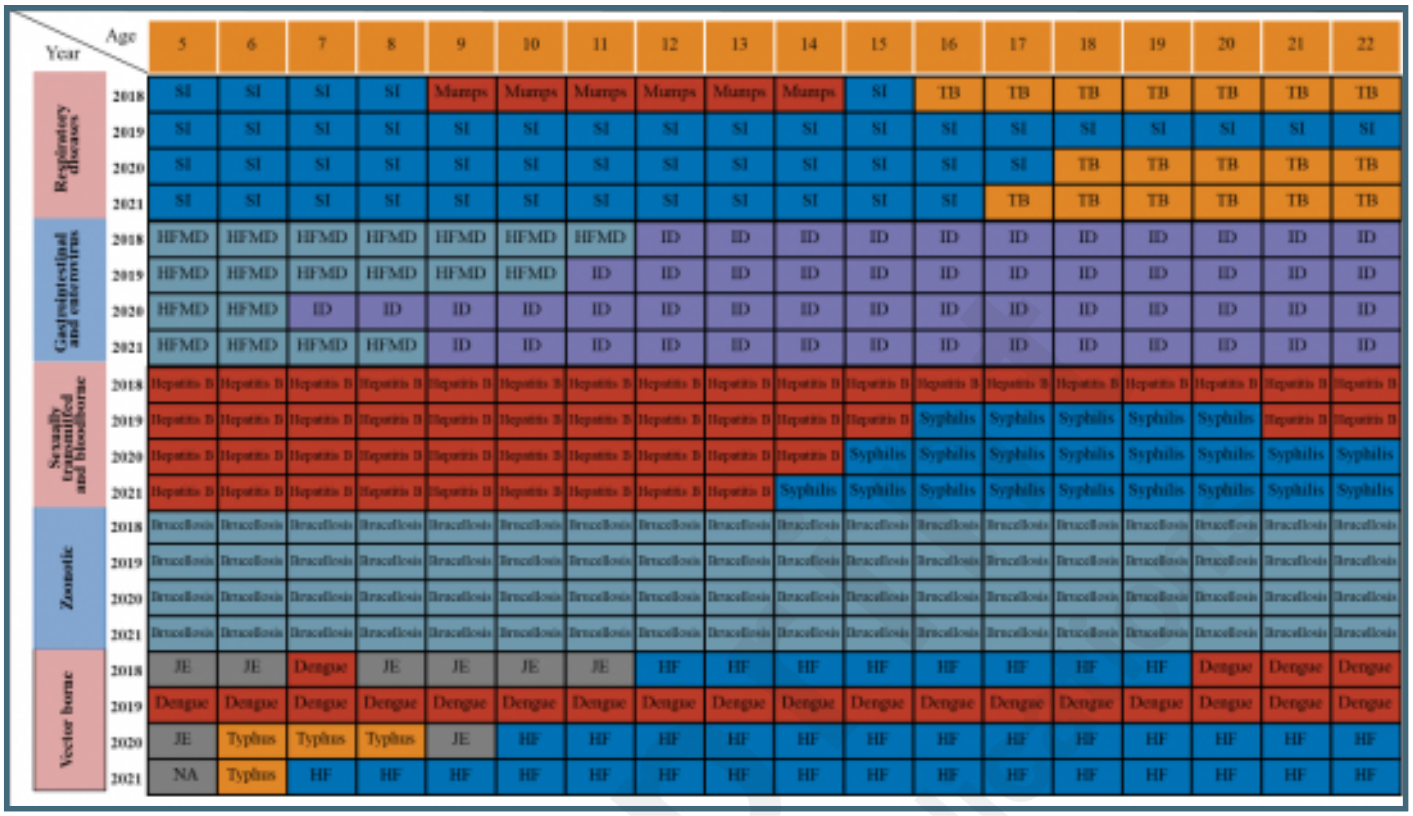
The trends in incidence (A), number of cases (B), and number of deaths (C) for 42 notifiable infectious diseases by disease category, from 2018 to 2021.



Temporal changes in incidence of infectious diseases by disease category and day, from 2018 and 2019 (pre-COVID-19), and year 1 (2020) and year 2 (2021) of the COVID-19 pandemic.

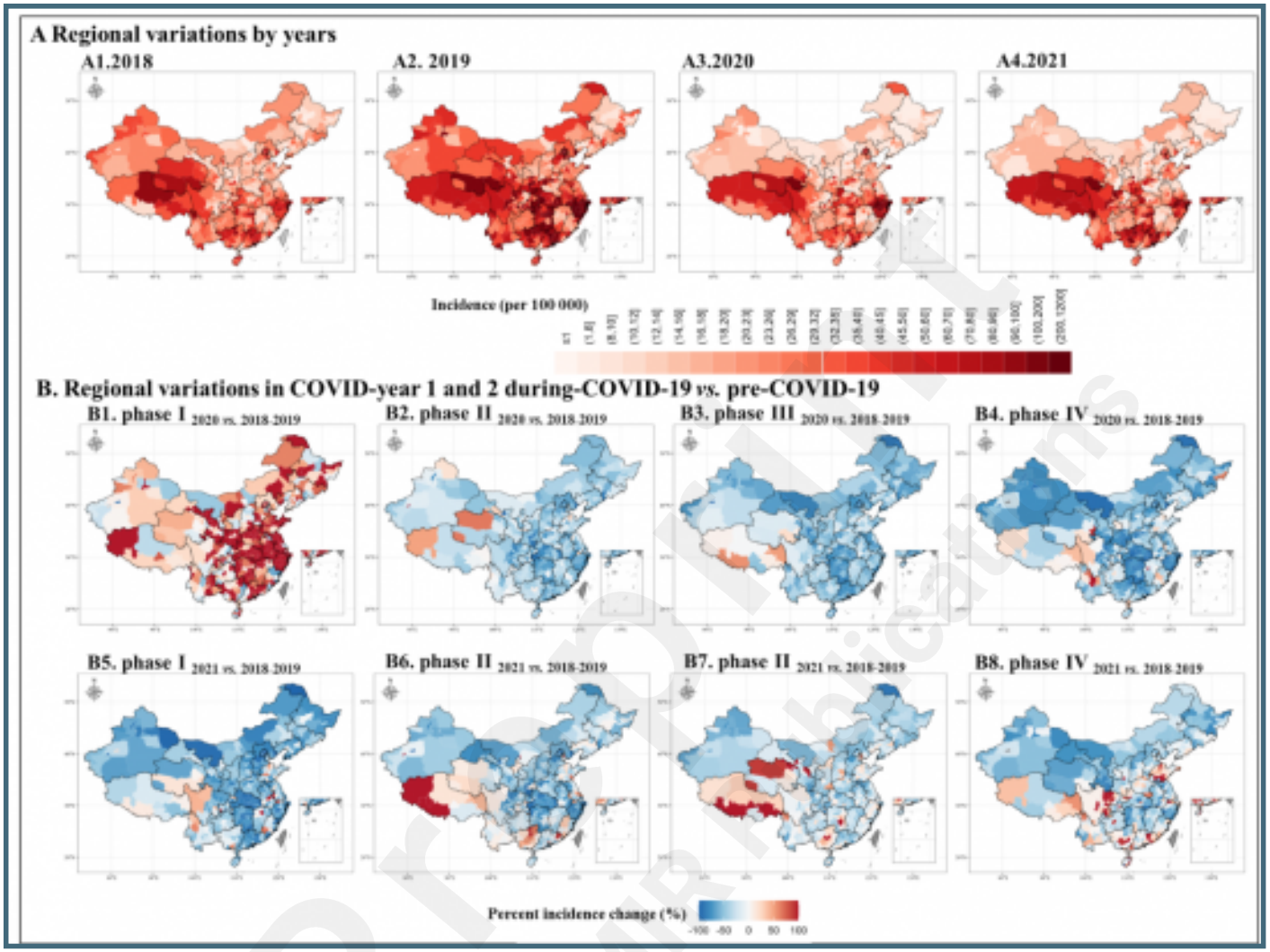


The leading infectious diseases by incidence by disease category and across age, from 2018 to 2021.

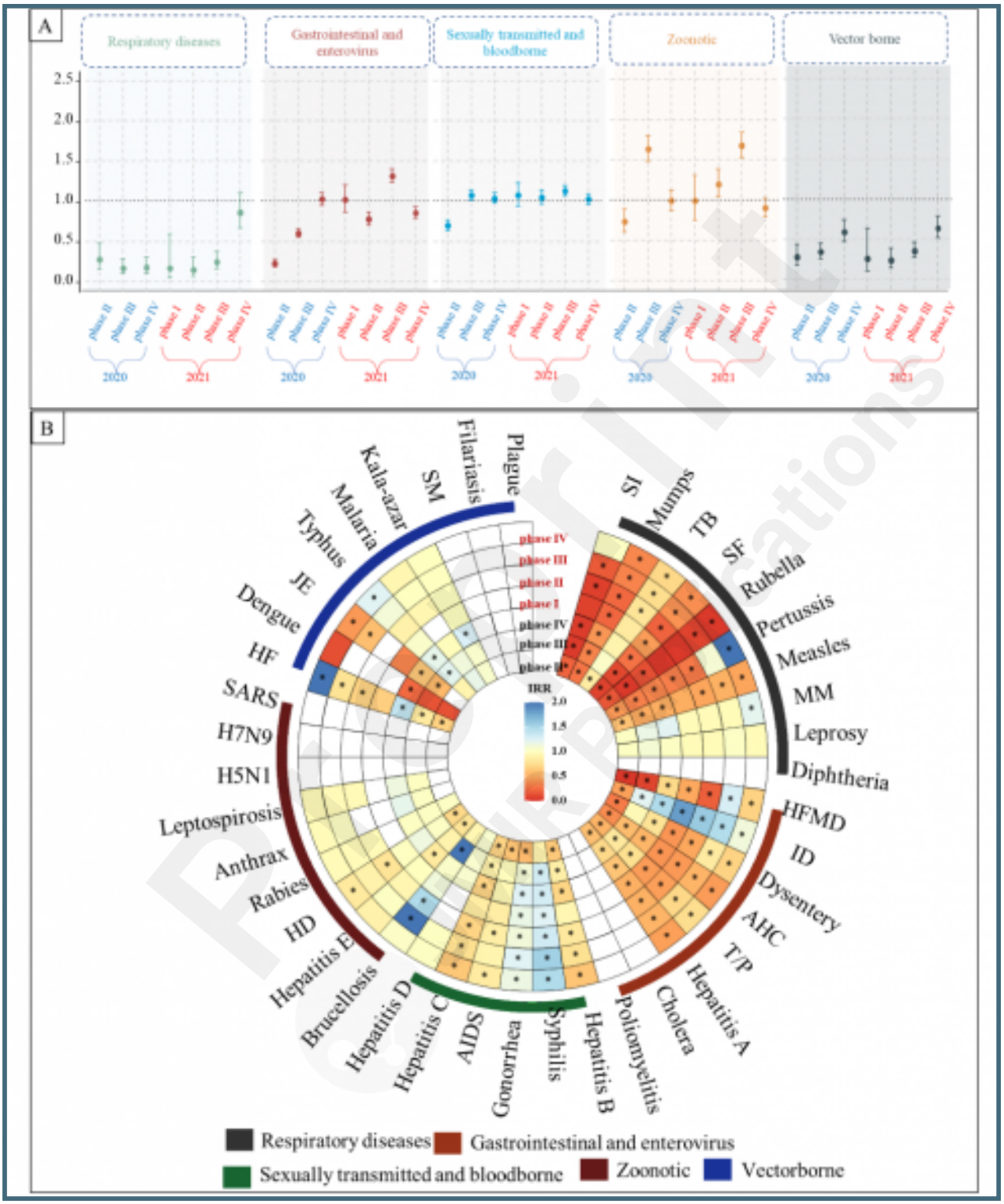


Category	Year	Age 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Respiratory diseases	2018	SI	SI	SI	SI	Mumps	Mumps	Mumps	Mumps	Mumps	Mumps	SI	TB	TB	TB	TB	TB	TB	TB
	2019	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
	2020	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	TB	TB	TB	TB	TB
	2021	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	TB	TB	TB	TB	TB	TB
Gastrointestinal and enteroviral	2018	HFMD	HFMD	HFMD	HFMD	HFMD	HFMD	HFMD	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	2019	HFMD	HFMD	HFMD	HFMD	HFMD	HFMD	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	2020	HFMD	HFMD	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	2021	HFMD	HFMD	HFMD	HFMD	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
Sexually transmitted and bloodborne	2018	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B
	2019	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Hepatitis B	Hepatitis B
	2020	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis
	2021	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Hepatitis B	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis	Syphilis
Zoonotic	2018	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis
	2019	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis
	2020	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis
	2021	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis	Brucellosis
Vector borne	2018	JE	JE	Dengue	JE	JE	JE	JE	HF	HF	HF	HF	HF	HF	HF	HF	Dengue	Dengue	Dengue
	2019	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue	Dengue
	2020	JE	Typhus	Typhus	Typhus	JE	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF
	2021	NA	Typhus	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF

Regional variation in infectious diseases incidence by year (A) and percent change of incidence in each epidemic phase during COVID-year 1 in 2020 and COVID-year 2 in 2021 compared to the average pre-COVID-19 levels for 2018-2019 at city level.



Incidence rate ratio (IRR) in each epidemic phase in 2020 and 2021 for five categories of 42 notifiable infectious diseases.



Multimedia Appendixes

The trends in number of cases, incidence, number of deaths and mortality rate for 42 notifiable infectious diseases by year and quarter.
URL: http://asset.jmir.pub/assets/704fb57c64a3c231b51ae0ad920d6926.docx

The changes in incidence (per100,000) and mortality (per 100,000) for 42 notifiable infectious diseases in China, from 2018 to 2021.
URL: http://asset.jmir.pub/assets/8de127c01fe38de32213d9130acf8d94.docx

The trends in incidence and proportion for 42 notifiable infectious diseases by disease category, from 2018 to 2021.
URL: http://asset.jmir.pub/assets/0c5e1696b2e98f9b43832b68c3703489.docx

Ranking of incidence of each 42 notifiable infectious disease by year, from 2018 to 2021.
URL: http://asset.jmir.pub/assets/39bf6f1b773abd9e71f74570e42490cc.docx

The incidence of five categories for 42 notifiable infectious diseases at city level, from 2018 to 2020.
URL: http://asset.jmir.pub/assets/998f096d2584ed8d1d6918ebbe899c8c.docx

The percent changes of cumulative incidence of five categories for 42 notifiable infectious diseases by epidemic phase at city level.
URL: http://asset.jmir.pub/assets/8d44f92a175de4a5ace1e2853259bb31.docx

Incidence of overall infectious diseases and percent changes of cumulative incidence in each epidemic phase between 2020, 2021 and the average of 2018?2019 at city level (excluding seasonal influenza).
URL: http://asset.jmir.pub/assets/1a8fc30197d5553e825c79e03d221961.docx

IRRs for incidence for 42 notifiable infectious diseases in China, from 2018 to 2021.
URL: http://asset.jmir.pub/assets/ee8d32f7ce7491dc5954d1c439b30b8e.docx

IRRs for incidence for 42 notifiable infectious diseases in North China, from 2018 to 2021.
URL: http://asset.jmir.pub/assets/7ca8b840c6ba4a907964b452900147d2.docx

IRRs for incidence for 42 notifiable infectious diseases in South China, from 2018 to 2021.
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