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The epidemiological trends of 40 national notifiable infectious diseases in China: An analysis of national surveillance data from 2013 to 2022

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ABSTRACT

Objective: It aims to provide a preliminary analysis of the epidemiological characteristics and trends of 40 notifiable infectious diseases in the mainland of China over the past ten years, serving as a valuable reference for public health policies and interventions related to infectious diseases.

Methods: Using data from the monthly analysis reports of the National Infectious Disease Surveillance System, we obtained information on reportable infectious diseases in China from 2013 to 2022. The data were analyzed using Excel 2010 software, and a joinpoint regression model was employed to examine trends in incidence and case-fatality ratios during this period.

Results: From 2013 to 2022, a total of 76 874 318 cases of notifiable infectious diseases were reported in the mainland of China, resulting in an average yearly incidence of 551.26/100 000 persons, with an average annual percentage change (AAPC) was 0.23% (95%*CI*: -3.81 to 4.37). The infectious diseases with the highest yearly incidence include hand, foot and mouth disease, hepatitis B, infectious diarrhea, tuberculosis, and influenza. There were 207 216 deaths with an average annual case-fatality rate of 2.70/1 000, with an AAPC of 5.53% (95%*CI*: 2.16 to 9.30). The diseases with the highest mortality rates were acquired immune deficiency syndrome (AIDS), tuberculosis, rabies, infectious diarrhea, and COVID-19. The incidence of notifiable infectious diseases was predominantly attributed to category C diseases, accounting for 54.50% of total cases, while intestinal infectious diseases were the most prevalent, comprising 40.64% of the total morbidity. The monthly incidence trend of 40 notifiable infectious diseases in China's mainland exhibited a "W" distribution, whereas the monthly case-fatality ratio trend displayed an "M" distribution.

Conclusions: It is crucial to continuously reinforce the prevention and control of key infectious diseases, including AIDS, tuberculosis, and viral hepatitis, as well as highly prevalent diseases such as hand, foot and mouth disease, influenza, and infectious diarrhea. Additionally, enhancing surveillance and response to emerging infectious diseases is essential to safeguarding public health and safety.

KEYWORDS: Epidemiology; Infectious Diseases; Incidence; Case-fatality rate

Significance

With advancements in basic sanitation, nutrition, medications, and vaccines, the overall incidence and mortality rates of infectious diseases in China have consistently declined. However, the threat posed by severe infectious diseases to both human and animal health remains significant, particularly with the emergence of novel infectious diseases and the resurgence and outbreaks of traditional ones. This study examines the incidence, mortality, and evolving patterns of legally notifiable infectious diseases in China over the past decade. Additionally, it explores the trends of these diseases in the context of emerging infectious threats, aiming to provide a reference for future efforts in infectious disease prevention and control.

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1. Introduction

Since the beginning of the 21st century, improvements in sanitation and nutrition, along with advancements in diagnostic and therapeutic techniques, vaccines and medications, have significantly contributed to the effective control and even elimination of numerous infectious diseases in China[1–5]. However, economic growth and accelerated urbanization have not been accompanied by strengthened prevention and control measures, leading to the resurgence and epidemic of traditional infectious diseases such as tuberculosis. Simultaneously, novel infectious diseases have emerged due to increased international exchanges and ecological changes, creating substantial economic burdens for the country and posing serious threats to public health and safety[6–7].

Currently, there are 40 notifiable infectious diseases in China. However, viral hepatitis is categorized into hepatitis A, B, C, D, E, and unclassified types, bringing the total number of notifiable infectious diseases to 45. According to the "Law of the People's Republic of China on the Prevention and Control of Infectious Diseases," notifiable infectious diseases are classified into three categories: Class A, Class B, and Class C. Among them, there are 2 diseases in Class A, 27 in Class B, and 11 in Class C[6,8,9].

Infectious disease surveillance is a critical public health monitoring task that requires both long-term continuity and an in-depth understanding of the epidemiological patterns of infectious diseases, as well as an evaluation of the effectiveness of interventions. China established a system for routine reporting of notifiable infectious diseases in the 1950s. Since 2003, the system has been updated to a web-based platform and operates through administrative grading responsibility and territorial management[9]. This system now covers data from 31 provinces in the mainland of China, encompassing approximately 1.4 billion people, providing strong support for the prevention and control of infectious diseases.

In this study, we extracted epidemic data reported by the National Infectious Disease Surveillance System (NIDSS) in the mainland of China (excluding Hong Kong, Macao, and Taiwan) from 2013 to 2022, including data from the COVID-19 epidemic. By analyzing the epidemiological characteristics and trends of infectious diseases over the past decade across the country, we aim to further explore and understand the epidemiological patterns of these diseases, evaluate the epidemic situation, and provide references and foundations for the formulation of strategies and measures for their prevention and control.

2. Methods

2.1. Data sources

The data were obtained from the monthly analysis reports of the NIDSS from 2013 to 2022, provided by the Division of Infectious Disease, Chinese Center for Disease Control and Prevention. These reports included the monthly numbers of cases and deaths related to infectious diseases. The annual population data for the years 2013 to 2022 were collected from the website of the National Bureau of Statistics of China.

2.2. Statistical analysis

Yearly incidence (per 100 000) was calculated as the number of reported cases per year divided by the mid-year population size. The fatality rate (per 1 000) was calculated as the number of reported deaths divided by the number of reported cases during the same period[9]. Additionally, radar charts based on the percentage of patients per month were used to characterize the distribution of the diseases throughout the year.

Microsoft Excel 2010 (Microsoft, Redmond, WA, USA) was used for data extraction, sorting, and cleaning. Joinpoint regression models[10–11] were applied to analyze trends in incidence and case-fatality rates from 2013 to 2022 and to identify changes in trends at different stages. The Joinpoint Regression Program Version 5.0.2 (Statistical Research and Applications Branch, National Cancer Institute) was used to construct the joinpoint regression models and calculate the annual percentage changes (APC) and average annual percentage changes (AAPC) to represent the trends.

APC is used to assess the internal trend within independent segments of a segmented function or to evaluate the overall trend when there are no joinpoints. To provide a comprehensive evaluation of the average global trend across multiple segments, AAPC is calculated. The empirical quantile confidence interval was applied for both APC and AAPC calculations. If the 95% confidence intervals (CIs) for AAPC are entirely >0 or <0, this indicates an increasing or decreasing trend, respectively. Conversely, if zero is included within the 95%*CI*, the trend is considered not significant and described as "stable"[6,8,9]. Additionally, 95% confidence intervals were calculated for both APCs and AAPCs, and hypotheses were tested using the Z test with a significance level set at $P<0.05$.

2.3. Ethics approval and consent to participate

The data in our study were reported by the Division of Infectious Disease, Chinese Center for Disease Control and Prevention, as part of routine surveillance, and all case information was anonymized.

3. Results

3.1. Overall incidence and case–fatality ratios

This study examined 40 infectious diseases from 2013 to 2022. During this 10-year period, a total of 76 874 318 cases of infectious diseases were reported, with an average annual incidence rate of 551.26 per 100 000 population. The five diseases with the highest average annual incidence rates include hand, foot, and mouth disease (HFMD), hepatitis B, infectious diarrhea, tuberculosis, and influenza, as shown in Figure 1A (Supplementary Table S1). There were 207 216 deaths reported among these cases, resulting in an average annual case-fatality ratio of 2.70 deaths per 1 000 cases. The highest mortality rates were associated with AIDS, tuberculosis, infectious diarrhea, COVID-19, and hepatitis C, while the highest case-fatality ratios were observed for rabies, H5N1 influenza, plague, H7N9 influenza, and AIDS, as illustrated in Figure 1B (Supplementary Table S1).

From 2013 to 2019, the annual incidence rate of infectious diseases increased by 48.83%, as reflected in the number of reported cases. Although the average annual incidence rate from 2020 to 2022 showed a significant decrease compared to the 2013-2019 period, it still exhibited an upward trend during these years, as illustrated in Figure 1C (Supplementary Table S2). Concurrently, the overall mortality rate for infectious diseases demonstrated an increasing trend from 2013 to 2022, which was consistent with the trend in the number of disease-related deaths. Interestingly, during the COVID-19 pandemic, the number of disease-related deaths did not show significant fluctuation and even exhibited a slight decrease. However, the rate of disease-related deaths experienced a relatively substantial increase, as shown in Figure 1D (Supplementary Table S2).

3.2. Epidemic trend of infectious diseases stratified by A, B and C

According to official statistical data from 2013 to 2022, the incidence of notifiable infectious diseases in China's mainland was primarily attributed to type C infectious diseases, accounting for 54.50% of all reported cases. Type B infectious diseases also represented a substantial proportion, contributing more than 45.49% of the total cases. In contrast, the incidence of type A infectious diseases was significantly lower, at less than 0.01% (Supplementary Figure S1, Tables S3 and S4). Overall, the incidence of all three types of infectious diseases remained stable, with an AAPC of 0.23% (95%*CI*: -3.81 to 4.37). However, the case-fatality ratio showed an increasing trend, with an AAPC of 5.53% (95%*CI*: 2.16 to 9.30).

For type A infectious diseases, both incidence and case-fatality rates were stable throughout the entire period; however, there was a decline in the case-fatality rate during the COVID-19 pandemic. For type B and C infectious diseases, different trends were observed. The incidence rate of type B infectious diseases decreased over the entire period and remained stable before and after the COVID-19 pandemic. Conversely, the case-fatality rate showed an increasing trend before the pandemic and stabilized during the pandemic. For type C infectious diseases, the overall incidence remained stable, with an upward trend in incidence rates both before and after the COVID-19 pandemic, while the case-fatality rate exhibited a decreasing trend throughout the entire period, with downward trends before and after the COVID-19 outbreak (Table 1).

Additionally, data from the three years before and after the COVID-19 outbreak were carefully analyzed for comparison (Supplementary Table S5). The average annual incidence rate during the outbreak period (2020–2022) decreased by 23.32% compared to the pre-outbreak period (2017–2019). The incidence rates of infectious diseases in types A, B, and C all declined, with type C experiencing the most significant decrease at 31.27%. However, the average annual case-fatality rate during the COVID-19 period showed an opposite trend, increasing by 39.04%. Notably, the case-fatality rate for type A and type B infectious diseases increased by 137.02% and 21.47%, respectively, while the case-fatality rate for type C infectious diseases decreased by 55.56%.

3.3. Epidemic trend of infectious diseases in different transmission routes

As shown in Figures 2A and 2B (Supplementary Tables S6 and S7), from 2013 to 2022, notifiable infectious diseases in China's mainland were predominantly characterized by intestinal infectious diseases, which accounted for 40.64% of all reported cases. Respiratory infectious diseases and infections transmitted through sexual contact, blood, and mother-to-child routes also made up significant proportions, comprising 30.82% and 26.90% of cases, respectively. In contrast, vector-borne diseases and other infections (contact transmission) constituted less than 1.00% of the total cases. Regarding deaths from these diseases, infections transmitted through sexual contact, blood, and mother-to-child routes were the leading causes, responsible for 83.19% of all deaths. Respiratory and zoonotic infectious diseases also contributed to mortality, accounting for 12.76% and 2.81% of deaths, respectively. In contrast, deaths due to intestinal, vector-borne, and other infections (contact transmission) were each less than 1.00%.

As presented in Table 2, the incidence and case-fatality rates of infectious diseases with different transmission routes exhibited considerable variation in epidemiological trends from 2013 to 2022. The trends for respiratory infectious diseases were generally stable throughout the entire period. However, there was a significant upward trend in incidence rates from 2013 to 2019, with an AAPC of 18.38% (95%*CI*: 1.97 to 37.42). Specifically, there was an increasing trend in the incidence of pertussis, while measles, tuberculosis, meningococcal meningitis, mumps, and leprosy showed decreasing trends. Additionally, the case-fatality rate of tuberculosis increased, while the case-fatality rate of influenza decreased. Intestinal infectious diseases demonstrated overall decreasing trends in both incidence and case-fatality rates, with AAPCs of -5.29% (95%*CI*: -10.28 to -0.02) and -24.77% (95%*CI*: -35.17 to -19.09), respectively. There were downward trends in the incidence of hepatitis A, other hepatitis, dysentery, typhoid fever and paratyphoid fever (TF&PF), and HFMD, as well as in the case-fatality rates of cholera, infectious diarrhea, and HFMD. Vector-borne infectious diseases showed a decreasing trend in incidence rates, with an AAPC of -17.54% (95%*CI*: -36.33 to -3.10), while case-fatality rates remained stable. There were declines in the incidence of malaria and typhus, but an increasing trend in the case-fatality rate of epidemic encephalitis B. The incidence of zoonotic diseases was generally stable, but there was a significant downward trend in case-fatality rates, with an AAPC of -17.28% (95%*CI*: -25.16 to -11.71). There were decreasing trends in the incidence of epidemic hemorrhagic fever (EHF) and rabies, and an increasing trend in the case-fatality rate of schistosomiasis. Infections transmitted through sexual, blood, and mother-to-child routes showed stable incidence trends but a significant increase in case-fatality rates, with an AAPC of 5.00% (95%*CI*: 3.52 to 6.50), particularly during 2013 to 2019. The incidence of hepatitis D showed a declining trend, while syphilis incidence increased. As for case-fatality rates, AIDS-related deaths increased throughout the period. Infectious diseases transmitted through other (contact transmission) routes generally showed decreasing trends in both incidence and case-fatality rates, with AAPCs of -3.74% (95%*CI*:

-6.88 to-0.49) and -33.44% (95%*CI*: -52.39 to -24.29), respectively. Notably, there were significant decreases in the incidence of acute hemorrhagic conjunctivitis (AHC) and neonatal tetanus.

According to the study findings, the average annual incidence rates of infectious diseases transmitted by all routes, except for zoonotic infectious diseases, decreased during the COVID-19 pandemic compared to the average of the three years preceding it (Supplementary Tables S6 and S7). Vector-borne infectious diseases experienced the most significant decrease, with an 80.17% reduction, followed by intestinal infectious diseases, which saw a 39.69% decrease. Regarding case-fatality rates, the average annual case-fatality rates for infectious diseases transmitted via intestinal, zoonotic, vector-borne, and other (contact transmission) routes during the pandemic were lower than those before the pandemic. Among these, zoonotic infectious diseases showed the most substantial decrease in case-fatality rates, with a reduction of 63.89%, followed by diseases transmitted through other (contact) routes, which decreased by 45.45% (Supplementary Tables S6 and S8). However, respiratory diseases and diseases transmitted through sexual, blood, and mother-to-child routes had higher case-fatality rates during the COVID-19 pandemic than before, with increases of 80.25% and 9.27%, respectively.

3.4. Seasonal distribution of infectious diseases

As shown in Figure 3A (Supplementary Table S9), the monthly incidence trend of notifiable infectious diseases in the mainland of China from 2013 to 2022 displays a “W” pattern, which includes the monthly incidence trends for the three years before and during the COVID-19 pandemic. It was noteworthy that the monthly incidence rates in the three years preceding the COVID-19 pandemic were higher than those in the overall 2013–2022 period, while the monthly incidence rates during the COVID-19 pandemic were lower than those in the 2013–2022 period, except for January. In comparison to the three years before the COVID-19 pandemic and the 2013–2022 period, the monthly case-fatality rates during the pandemic were generally higher, except in January and November. Analyzing the average seasonal index for each month of notifiable infectious disease incidence in the mainland of China from 2013 to 2022, the results indicate that the seasonal indexes for January, May through July, and December were 1.08, 1.15, 1.31, 1.23, and 1.07, respectively. These values suggested that the number of cases in these months was higher than the average for the entire year, as illustrated in Figure 3B. The seasonal index for case fatalities was 1.03, 1.07, 1.15, and 1.30 for the months of August–September and November–December, respectively, indicating that the number of case fatalities in these months was higher than the average, as shown in Figure 3C.

Additionally, this study employed radar charts to illustrate the monthly incidence and case-fatality trends for each infectious disease. In terms of monthly incidence rates, 9 infectious diseases demonstrated significant seasonal patterns, 19 exhibited aggregated seasonal characteristics, and 15 showed no noticeable seasonal trends. For monthly case-fatality rates, 11 infectious diseases displayed significant seasonal characteristics, 22 exhibited aggregated seasonal trends, and 6 showed no significant seasonal patterns (Supplementary Figure S2).

Table 1. Annual percentage change in incidence and case-fatality ratios of 40 infectious diseases from 2013 to 2022.

Items	Yearly incidence (per 100 000)						Case-fatality ratios (per 1 000)					
	Periods	APC/AAPC (95%*CI*)	Trend	Periods	APC/AAPC (95%*CI*)	Trend	Periods	APC/AAPC (95%*CI*)	Trend	Periods	APC/AAPC (95%*CI*)	Trend
Time	Overall	0.23 (-3.81 to 4.37)	Stable	2013-2019	5.66* (0.36 to 11.23)	Increase	Overall	5.53* (2.16 to 9.30)	Increase	2013-2019	1.80 (-2.03 to 6.39)	Stable
				2020-2022	7.68* (5.83 to 9.68)	Increase				2020-2022	-7.95* (-13.79 to -1.65)	Decrease
Types A		-7.16 (-17.27 to 4.18)	Stable	2013-2019	-12.72 (-27.26 to 4.73)	Stable		5.22 (-10.74 to 22.69)	Stable	2013-2019	-1.37 (-31.23 to 41.47)	Stable
				2020-2022	57.82 (-7.74 to 241.69)	Stable				2020-2022	-61.11* (-67.39 to -56.93)	Decrease
Types B		-1.63* (-2.51 to -0.78)	Decrease	2013-2019	-0.32 (-1.39 to 0.77)	Stable		7.33* (5.09 to 9.88)	Increase	2013-2019	8.03* (5.87 to 10.23)	Increase
				2020-2022	-0.02 (-1.52 to 1.52)	Stable				2020-2022	-0.64 (-9.96 to 9.78)	Stable
Types C		1.96 (-5.25 to 9.79)	Stable	2013-2019	10.87* (1.99 to 20.52)	Increase		-17.0* (-31.25 to -5.65)	Decrease	2013-2019	-16.34* (-29.63 to -3.53)	Decrease
				2020-2022	15.01* (10.16 to 20.54)	Increase				2020-2022	-66.20* (-86.27 to -48.57)	Decrease

APC: annual percent change; AAPC: average annual percent change. * $p<0.05$

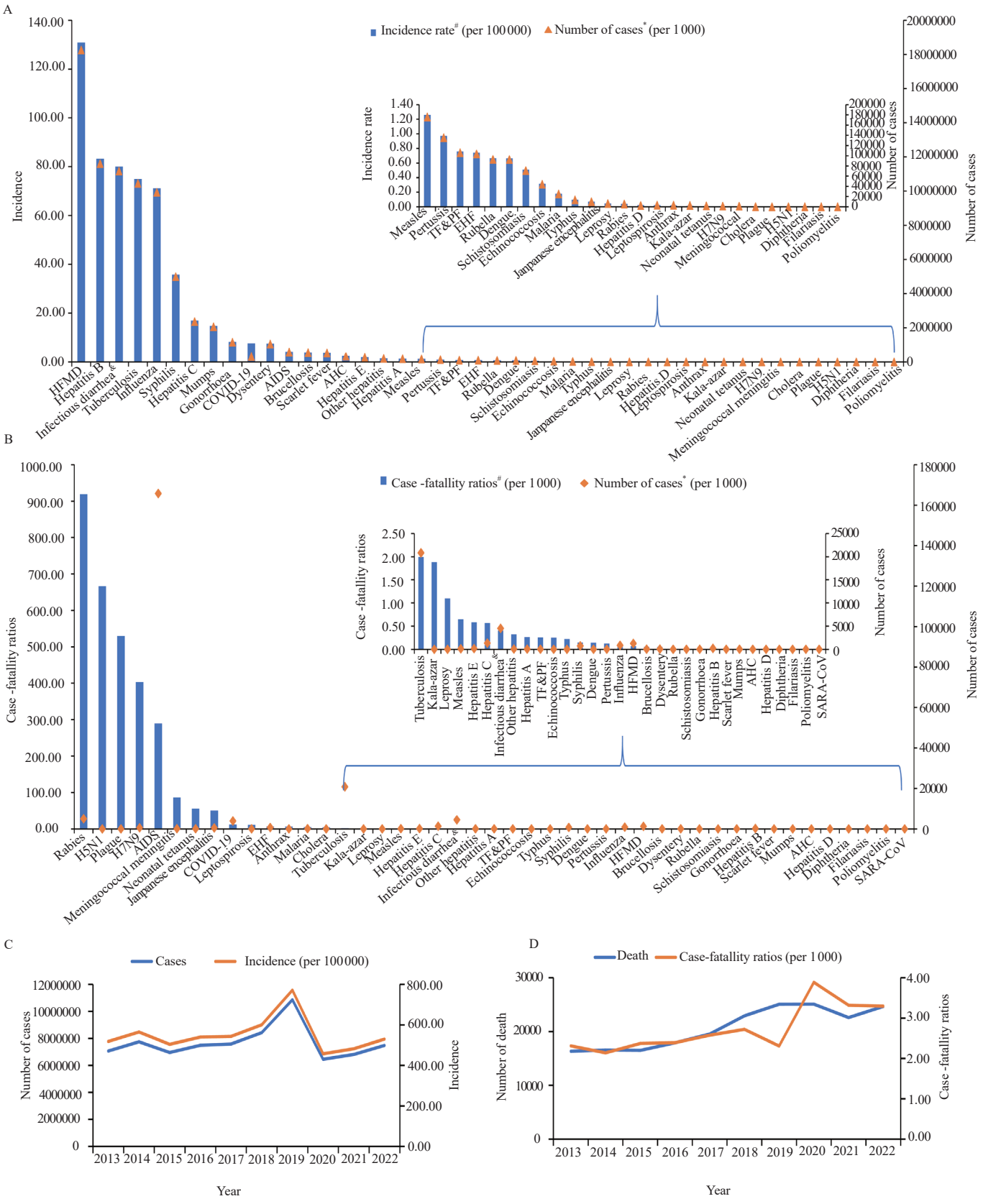

Figure 1. Incidence and case-fatality ratios data for 40 notifiable infectious diseases from 2013 to 2022 in China. (A) Incidence of 40 notifiable infectious diseases; (B) Case-fatality ratios of 40 notifiable infectious diseases; (C) Number of cases and incidence rates per year between 2013 and 2022; (D) Number of deaths and case-fatality ratios per year between 2013 and 2022. *Total numbers for 10 years; #Average for 10 years; &Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever; HFMD: Hand, foot, and mouth disease; AIDS: Acquired immune deficiency syndrome; AHC: Acute haemorrhagic conjunctivitis; TF&PF: Typhoid fever and paratyphoid fever; EHF: Epidemic hemorrhagic fever; H7N9: Human infection with H7N9 virus; H5N1: Human infection with H5N1 virus; SARS: Severe acute respiratory syndrome.

Table 2. Annual percentage change in incidence of 40 infectious diseases, from 2013 to 2022.

Types of transmission routes	Yearly incidence†				Case-fatality ratios†				Types of infectious diseases	Yearly incidence†		Case-fatality ratios†	
	Periods	APC/AAPC (95% *CI*)	Periods	APC/AAPC (95% *CI*)	Periods	APC/AAPC (95% *CI*)	Periods	APC/AAPC (95% *CI*)		APC/AAPC (95% *CI*)	Trend	APC/AAPC (95% *CI*)	Trend
Respiratory	overall	8.25 (-0.62 to19.37)	2013-2019	18.38* (1.97 to 37.42)	overall	2.34 (-6.94 to 14.42)	2013-2019	-8.41 (-20.84 to 5.97)	SARS-CoV	-	-	-	-
									H5N1	-11.37 (-34.29 to 19.53)	Stable	-	-
									H7N9	32.00 (-16.56 to 132.08)	Stable	-	-
									Measles	-33.28* (-48.21 to -14.03)	Decrease	-7.47 (-15.44 to 1.25)	Stable
									Tuberculosis	-5.70* (-7.28 to -4.09)	Decrease	13.20* (4.49 to 22.62)	Increase
									Meningococcal meningitis	-12.53* (-17.56 to -8.61)	Decrease	-3.34 (-11.11 to 2.38)	Stable
									Pertussis	25.90* (12.13 to 54.64)	Increase	-23.36 (-43.34 to 1.98)	Stable
									Diphtheria	3.34 (-11.56 to 20.74)	Stable	-	-
									Scarlet fever	-3.98 (-16.75 to 10.76)	Stable	6.20 (-12.57 to 29.01)	Stable
			2020-2022	26.50 (-11.54 to 92.13)			2020-2022	-23.02 (-46.15 to 9.08)	COVID-19	-	-	-	-
									Influenza	28.25 (-3.04 to 69.66)	Stable	-20.27* (-33.40 to -4.55)	Decrease
									Mumps	-6.79* (-14.13 to -0.04)	Decrease	7.14 (-11.41 to 25.12)	Stable
									Rubella	1.24 (-17.94 to 20.50)	Stable	29.16 (-7.48 to 80.31)	Stable
									Leprosy	-11.28* (-13.29 to -9.68)	Decrease	-7.47 (-15.44 to 1.25)	Stable
Intestinal	overall	-5.29* (-10.28 to -0.02)	2013-2019	0.23 (-5.18 to 6.02)	overall	-24.77* (-35.17 to -19.09)	2013-2019	-26.51* (-45.75 to -11.85)	Cholera	-8.13 (-23.62 to 5.16)	Stable	-59.03* (-72.79 to -38.30)	Decrease
									Hepatitis A	-8.28* (-11.07 to -5.41)	Decrease	-6.93 (-16.70 to 3.99)	Stable
									Hepatitis E	-1.79 (-4.69 to 1.18)	Stable	-2.57 (-9.13 to 3.77)	Stable
									Other hepatitis	-17.29* (-18.85 to -15.70)	Decrease	-0.10 (-11.66 to 12.97)	Stable
									Poliomyelitis	-	-	-	-
									Dysentery	-15.27* (-17.06 to -13.45)	Decrease	1.84 (-22.39 to 13.91)	Stable
			2020-2022	-4.51 (-32.52 to 34.32)			2020-2022	-19.12 (-44.83 to 13.27)	TF&PF	-8.81* (-10.88 to -6.69)	Decrease	8.62 (-10.81 to 32.29)	Stable
									Infectious diarrhea	2.23 (-1.73 to 6.34)	Stable	-14.70* (-21.59 to -9.15)	Decrease
									HFMD	-8.83* (-16.09 to -0.95)	Decrease	-32.30* (-50.38 to -23.60)	Decrease

Table 2. Continued.

Types of transmission routes	Periods	Yearly incidence† APC/AAPC (95% *CI*)	Periods	APC/AAPC (95% *CI*)	Periods	Case-fatality ratios† APC/AAPC (95% *CI*)	Periods	APC/AAPC (95% *CI*)	Types of transmission routes	Yearly incidence† APC/AAPC (95% *CI*)	Trend	Case-fatality ratios† APC/AAPC (95% *CI*)	Trend
									Epidemic encephalitis B	-15.27 (-28.38 to 0.23)	Stable	16.42* (2.33 to 32.44)	Increase
			2013-2019	-10.96 (-34.12 to 14.46)			2013-2019	10.66 (-17.57 to 55.50)	Dengue	-17.27 (-43.27 to 2.98)	Stable	5.43 (-11.71 to 25.90)	Stable
Vector born	overall	-17.54* (-36.33 to -3.10)			overall	5.77 (-26.08 to 46.81)			Malaria	-13.49* (-19.24t o -7.33)	Decrease	-1.12 (-12.66 to 7.37)	Stable
									Typhus	-4.95* (-9.38 to -0.29)	Decrease	9.44 (-22.00 to 53.57)	Stable
			2020-2022	-7.88 (-23.71 to 10.67)			2020-2022	-25.08* (-37.46 to -13.74)	Kala-azar	-4.87 (-15.69 to 5.68)	Stable	-0.93 (-8.08 to 6.78)	Stable
									Filariasis	-0.66 (-3.92 to 2.54)	Stable	-	-
									Plague	1.38 (-19.39 to 39.96)	Stable	-	-
			2013-2019	-6.77 (-18.20 to 6.25)			2013-2019	-14.13* (-24.93 to -1.79)	EHF	-5.77* (-10.15 to -1.71)	Decrease	-2.60 (-11.49 to 5.97)	Stable
									Rabies	-21.19* (-22.94 to -19.40)	Decrease	-0.22 (-2.64 to 1.27)	Stable
Zoonotic	overall	-2.29 (-7.86 to 3.26)			overall	-17.28* (-25.16 to -11.71)			Anthrax	3.05 (-2.20 to 8.93)	Stable	-4.26 (-19.10 to 12.42)	Stable
									Brucellosis	2.62 (-2.48 to 7.99)	Stable	3.88 (-8.06 to 19.87)	Stable
			2020-2022	11.78 (-3.66 to 30.91)			2020-2022	-30.72* (-32.92 to -28.69)	Leptospirosis	-5.51 (-13.97 to 2.22)	Stable	1.01 (-13.50 to 15.61)	Stable
									Schistosomiasis	-21.61 (-64.38 to 72.54)	Stable	88.82* (66.65 to 113.95)	Increase
									Echinococcosis	-3.26 (-9.98 to 3.95)	Stable	12.71 (-1.79 to 29.36)	Stable
									AIDS	2.83 (-0.51 to 6.29)	Stable	3.91* (2.44 to 5.40)	Increase
			2013-2019	2.90* (1.55 to 4.28)			2013-2019	6.76* (4.56 to 9.02)	Hepatitis B	0.97 (-0.50 to 2.51)	Stable	-2.37 (-6.30 to 1.61)	Stable
Sexual, blood and mother-to-child borne	overall	1.15 (-0.14 to 2.46)			overall	5.00* (3.52 to 6.50)			Hepatitis C	0.19 (-1.25 to 1.65)	Stable	3.65 (-4.85 to 12.91)	Stable
									Hepatitis D	-13.35* (-18.36 to -8.55)	Decrease	-	-
			2020-2022	-0.06 (-5.20 to 5.40)			2020-2022	0.42 (-1.30 to 2.21)	Gonorrhea	1.00 (-2.67 to 4.81)	Stable	12.34 (-5.10 to 42.25)	Stable
									Syphilis	2.07* (0.31 to 3.86)	Increase	-5.04 (-11.50 to 1.28)	Stable
			2013-2019	0.06 (-4.30 to 4.62)			2013-2019	-35.74* (-51.21 to -15.38)	AHC	-3.56* (-6.73 to -0.28)	Decrease	-11.36 (-75.45 to 25.88)	Stable
Other (contact transmission)	overall	-3.74* (-6.88 to -0.49)	2020-2022	-4.20* (-6.81 to -1.53)	overall	-33.44* (-52.39 to -24.29)	2020-2022	-44.00* (-65.70 to -22.66)	Neonatal tetanus	-31.81* (-36.28 to -29.62	Decrease	-9.69 (-23.81 to 7.06)	Stable

Note: †When the number of cases or deaths data contained zero, we substitute 1‰ for zero to calculate the incidence and case-fatality rates. APC: Annual percent change; AAPC, Average annual percent change. *$P< 0.05$.

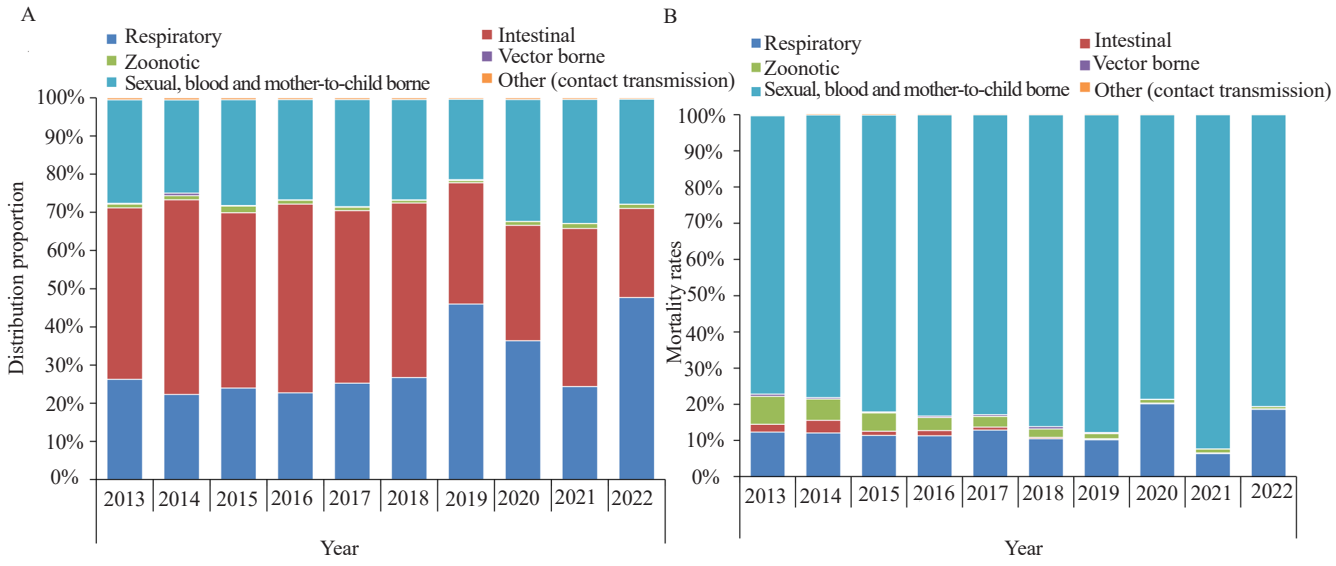

Figure 2. Distribution and mortality of notifiable infectious diseases in the mainland of China (2013-2022).

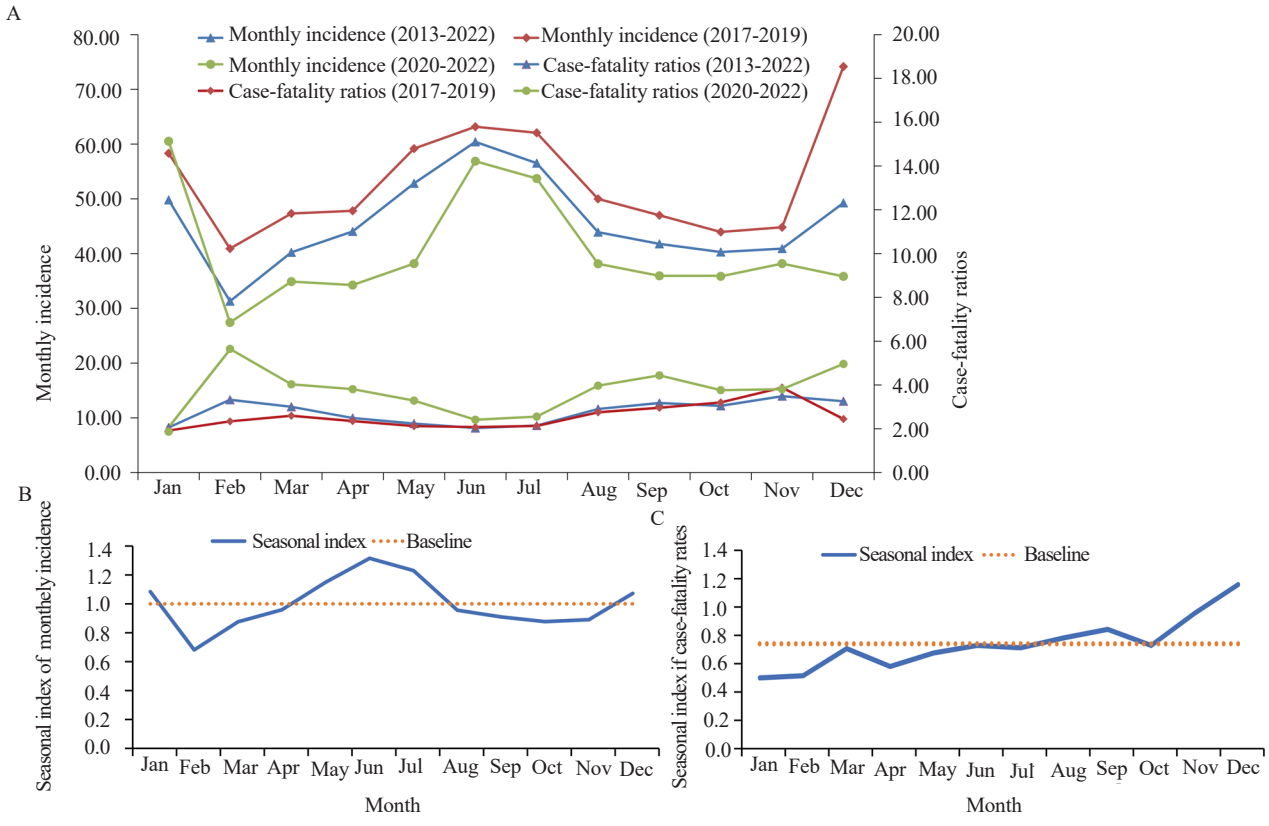

Figure 3. Monthly incidence and case-fatality trends of notifiable infectious diseases in the Mainland of China (2013-2022).

4. Discussion

Based on research findings over the years[6,9,12–14], infectious diseases have been closely linked to societal development in the 21st century. Their incidence and mortality rates have continued to rise, posing a significant threat to public health. Following the SARS outbreak in 2003, the State Council of the People's Republic of China introduced the Emergency Regulations for Public Health Emergencies[14]. Subsequently, the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases was revised in 2004 and 2013[14–15]. With the implementation of various strategies to curb the spread of infectious diseases[16–17], including enhanced blood collection safety, large-scale vector control, and improved early monitoring and warning systems,

substantial progress has been made in infectious disease prevention and control. These achievements include the elimination of filariasis in 2006, neonatal tetanus in 2012, and malaria in 2021[18–20]. However, outbreaks and epidemics of emerging infectious diseases, such as COVID-19, continue to pose new challenges to infectious disease prevention and control and to public health.

In this study, the incidence of reportable diseases and the case-fatality rate showed a gradual upward trend from 2013 to 2019, with the case-fatality rate rising particularly sharply. Several factors may explain this trend. Firstly, increased public health awareness has led to greater attention to the prevention, diagnosis, and treatment of various diseases, contributing to a rise in reported disease incidence. Secondly, advancements in diagnostic capabilities have resulted in higher reported incidence rates[9,21]. Thirdly, despite significant improvements in disease treatment, there remains a lack of willingness among many individuals to seek treatment, compounded by insufficient public knowledge about many diseases. Additionally, the threat of infection continues to escalate due to rising antimicrobial resistance, increased population mobility, changing human behaviors, and the emergence and spread of new infectious diseases[9]. During the COVID-19 pandemic (2020-2022), the average annual incidence rate of infectious diseases decreased by 23.32% compared to the pre-outbreak period (2017-2019). Most infectious diseases showed a significant decline in incidence, likely due to the effectiveness of non-pharmacological interventions[22]. Measures such as lockdowns, social distancing, enhanced hygiene practices, and isolation and control efforts to curb COVID-19 also helped prevent the spread of other pathogens, particularly respiratory infections[23,24]. Furthermore, the focus on COVID-19 may have led to reduced surveillance and reporting of other infectious diseases, resulting in fewer reported cases[25,26]. However, during the COVID-19 period, the average annual case-fatality rate increased by 39.04%, despite a decrease in the total number of deaths from these diseases. This rise in case-fatality rates was mainly due to a decrease in the number of reported cases. For some diseases, such as AIDS, the number of deaths increased. This may be related to patients' reluctance to seek timely medical care due to stigma and the constraints and inadequacies of medical resources during the COVID-19 pandemic, which could have led to delays or insufficient treatment and resuscitation for some patients.

From the perspective of the disease spectrum, there is a noticeable concentration in the number of cases and deaths of reportable infectious diseases in China. The top five diseases with the highest number of cases—HFMD, hepatitis B, infectious diarrhea, tuberculosis, and influenza—accounted for 79.88% of the total reported cases, highlighting their significant impact. Similarly, the top five diseases with the highest number of deaths—AIDS, tuberculosis, rabies, infectious diarrhea, and COVID-19—were responsible for 96.56% of all deaths, underscoring their lethality. As a populous country, China faces significant challenges with infectious diseases due to its economic development and population mobility. Major infectious diseases such as AIDS, tuberculosis, viral hepatitis, and emerging infectious diseases continue to pose substantial public health challenges. Despite the implementation of policies to strengthen AIDS education, prevention, intervention, testing, and treatment[27–28], the incidence and case-fatality rates of AIDS have been increasing in recent decades. Although these measures have effectively reduced the risk of transmission and fatality, the situation remains serious. Sexual transmission has become the primary route of AIDS in China, necessitating continued monitoring of AIDS patients, robust promotion of AIDS prevention and treatment knowledge, and advocacy for safe behaviors[29]. For tuberculosis, the incidence has shown a significant downward trend from 2013 to 2022, primarily due to the comprehensive coverage of the directly observed treatment, short-course (DOTS) strategy, and the implementation of various tuberculosis prevention and treatment plans[30]. However, the decline observed during the COVID-19 pandemic may be attributed to disruptions in timely diagnosis and treatment due to epidemic control measures. Despite these efforts, the effectiveness of tuberculosis prevention and control in China still falls short of the WHO's goal of ending tuberculosis by 2035. Future efforts should focus on targeted prevention and control in high-incidence areas and among vulnerable populations. And viral hepatitis also presents high incidence and case-fatality rates, with hepatitis B being particularly concerning. Since the hepatitis B vaccine was included in the national immunization program, the incidence of hepatitis B among children has been effectively controlled. However, hepatitis B cases are now mainly concentrated among adults aged 20 and above. Therefore, efforts should be intensified to promote hepatitis B vaccination and increase the immunization rate among adults to enhance population immunity and reduce hepatitis B incidence. Furthermore, the prevalence of viral hepatitis, particularly chronic hepatitis B and C, remains significant[31,32], necessitating enhanced screening and antiviral therapy for affected patients.

Over the past decade, type C infectious diseases have been the most prevalent, accounting for 54.5% of cases, primarily due to the high incidence of HFMD, infectious diarrhea, and influenza. During the COVID-19 pandemic, the incidence of type C diseases decreased by 31.27% compared to the three years prior. HFMD predominantly affects children under 5 years of age and is a common disease that requires increased dissemination of prevention and treatment knowledge to parents and teachers, as well as strengthened vaccination efforts[33,34]. The incidence of infectious diarrhea has remained stable in recent years, with a significant decline in the case-fatality rate, likely due to improved diagnostic and treatment capacities and heightened public awareness. In contrast, the incidence of influenza has rapidly increased over the past decade, with low vaccine coverage being a major factor contributing to its high prevalence[35–37]. This high incidence also increases the risk of death in specific populations, especially those over 60 years old[38]. Therefore, enhancing influenza surveillance and increasing

vaccination rates in these high-risk groups are crucial future steps[39,40]. The COVID-19 pandemic in 2020 underscored the need for effective prevention, control, and close monitoring of infectious diseases. This includes strengthening health education, advancing vaccine research and development, and promoting the prevention and use of existing vaccines[38].

From a transmission perspective, intestinal, respiratory, and sexually/blood/mother-to-child transmitted diseases continue to be the primary contributors to infectious disease prevalence, with intestinal infectious diseases being particularly severe. These diseases are largely due to inadequate hygiene practices, such as poor food and water sanitation[41]. The COVID-19 pandemic significantly impacted the incidence of gastrointestinal infectious diseases, with studies showing a notable reduction in cases and detection rates of rotavirus and adenovirus in 2020 compared to 2019[42]. Respiratory infectious diseases are primarily transmitted through droplets and airborne particles[43,44]. Preventive measures implemented to control COVID-19, such as mask-wearing and social distancing, have also reduced the incidence of respiratory syncytial virus, influenza, adenovirus, and other respiratory infections[45]. Both intestinal and respiratory transmission are closely related to public hygiene practices. The COVID-19 pandemic has not only led to significant changes in hygiene behaviors but has also improved public health literacy[46–49]. Blood-borne and sexually transmitted diseases showed a notable decline, particularly in February 2020, followed by a fluctuating rebound[25]. Seasonally, infectious diseases exhibited two peaks between 2013 and 2022, occurring in summer and winter. Intestinal infectious diseases primarily peaked between May and July, while respiratory infectious diseases peaked in January, June-July, and December. High temperatures and humidity in the summer facilitate the multiplication and spread of pathogens, whereas cold and dry winter conditions favor the survival and spread of viruses. To address the seasonal variations in disease prevalence, timely and real-time preventive and control measures can be implemented. These measures include ensuring adequate influenza vaccination coverage, enhancing public education on health and hygiene practices, *etc*.

To effectively prevent and control infectious diseases, China has implemented a series of measures, transitioning from non-synergistic to cooperative, multi-sectoral, and One Health integrated prevention and control strategies[7,16–17,50]. Through interdisciplinary collaboration and combined prevention and control efforts, the country has achieved remarkable progress in the prevention and treatment of infectious diseases.

Our study has some limitations. Firstly, the data we utilized were sourced from publicly available government information. However, these datasets lack comprehensive details on the regional distribution, age, and gender composition of each infectious disease, which prevented us from conducting further analysis on the spatial distribution, regional differences, and high-risk groups of notifiable infectious diseases. Secondly, relying on data from the reporting system might lead to an underestimation of annual incidence rates due to variations in screening intensity. Some infectious diseases may not be adequately screened for various reasons, leading to their incidence rates being underestimated. Furthermore, the incidence of certain infectious diseases may also be underestimated due to self-selection ascertainment bias, where individuals with a particular infectious disease might avoid screening more often than those without it. This implies that even if someone knows they have a particular infectious disease, they may choose not to be screened, resulting in an underestimation of the disease's incidence. Additionally, potential biases may arise due to differences in diagnostic criteria, skill levels, and laboratory conditions across different sectors or institutions, which could affect the accuracy of incidence and case-fatality reporting.

5. Conclusions

This study underscores the remarkable strides that China has taken in combating infectious diseases. These achievements owe not only to the proactive involvement and effective management of governmental bodies but also to the widespread engagement and collective endeavors of all sectors of society. Despite these advancements, critical infectious diseases like AIDS, tuberculosis, and viral hepatitis, alongside highly prevalent ailments such as hand-foot-mouth disease, influenza, and infectious diarrhea, persist in posing serious threats to public health. The swift dissemination and profound impact of these diseases entail significant economic strain and psychological stress on communities.

Furthermore, the persistent risk of recurring outbreaks of existing infectious diseases and the looming threat of novel infectious diseases present ongoing challenges to global public health. It is imperative that we remain vigilant, continuously fortify preventive and control measures, and bolster public health awareness and self-protection capabilities. Through concerted efforts, we can collectively safeguard societal harmony and stability, as well as the health and well-being of our populace.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' contributions

Zhou HR, Ye KY, Xiao N and Ai L designed the study. Zhou HR, Wang XL, Zhou Z, Wang YF and Hu JF collected the materials. Zhou HR, Wang XL and Wang XM analyzed the data. Zhou HR and Wang XL drafted the initial manuscript. Li GF, Ye KY, Xiao N and Ai L contributed to the critical revision of the article. Zhou HR, Wang XL, Ye KY, Xiao N and Ai L reviewed and edited the content of the whole paper. All authors reviewed subsequent drafts of the manuscript and approved the final version.

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