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Research article

Dynamics of respiratory infectious diseases under rapid urbanization and COVID-19 pandemic in the subcenter of Beijing during 2014–2022

Chang-Yu Guo [a,b], Wan-Xue Zhang [a,b], Yi-Guo Zhou [a,c], Shan-Shan Zhang [a,d], Lu Xi [e], Ran-Ran Zheng [e], Juan Du [a,b], Jianming Zhang [e,**], Yan Cui [e,***], Qing-Bin Lu [a,b,c,d,f,*]

[a] Department of Laboratorial Science and Technology, Vaccine Research Center, School of Public Health, Peking University, Beijing, China
[b] Center for Infectious Disease and Policy Research & Global Health and Infectious Diseases Group, Peking University, Beijing, China
[c] Department of Health Policy and Management, School of Public Health, Peking University, Beijing, China
[d] Department of Epidemiology and Biostatistics, School of Public Health, Peking University, Beijing, China
[e] Institute for Infectious Diseases and Endemic Diseases Prevention and Control, Beijing Tongzhou Center for Diseases Prevention and Control, Beijing, China
[f] Key Laboratory of Epidemiology of Major Diseases (Peking University), Ministry of Education, Beijing, China

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ABSTRACT

Objective: The study analyzed the impact of urbanization on epidemiological characteristics of respiratory infectious disease in Tongzhou District, Beijing during 2014–2022 to provide reference for prevention and control priorities of respiratory infectious diseases during the innovative urbanization process in China.

Methods: The incidence data of notifiable respiratory infectious diseases (NRIDs) in Tongzhou Beijing during 2014–2022 were summarized. The trend of incidence rate was analyzed by Joinpoint regression model, and entropy method was performed to construct the comprehensive index of urbanization (CIU) and generalized linear model was used to analyze the influence of CIU on the incidence rate of respiratory infectious diseases.

Results: Totally 72616 NRIDs cases were reported in Tongzhou District during 2014–2022, and the incidence rate of NRIDs was higher during 2017–2019 (153/100 000) than during 2014–2016 (930/100 000) and during 2020–2022 (371/100 000), respectively (both $P < 0.001$). The CIU constantly increased with slight fluctuation in 2016 and 2018, respectively. The incidence rate of NRIDs showed an increase along with the CIU during 2014–2019 ($r = 0.95$, $P = 0.004$), while the incidence rate's tendency was interrupted by COVID-19 during 2020 with slight decrease in 2020–2021 and rebounded in 2022. For the patients aged <15 years, the incidence rate of NRIDs revealed a very sharp rise at the urbanization period without COVID-19 pandemic compared with

* Corresponding author. Center for Infectious Disease and Policy Research & Department of Laboratorial of Science and Technology, School of Public Health, Peking University, No 38 Xue-Yuan Rd, Haidian District, Beijing 100191, China.
** Corresponding author. Institute for Infectious Diseases and Endemic Diseases Prevention and Control, Beijing Tongzhou Center for Diseases Prevention and Control, No 1 Luhe zhongxue North St, Tongzhou District, Beijing 101100, China.
*** Corresponding author. Institute for Infectious Diseases and Endemic Diseases Prevention and Control, Beijing Tongzhou Center for Diseases Prevention and Control, No 1 Luhe zhongxue North St, Tongzhou District, Beijing 101100, China.
E-mail addresses: zjm871004@163.com (J. Zhang), cuiyan_sxmu@163.com (Y. Cui), qingbinlu@bjmu.edu.cn (Q.-B. Lu).

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that under pre-urbanization period (RR = 7.93, 95 % CI 7.63–8.24), and dropped off to the similar level as of pre-urbanization period when COVID-19 pandemic spread.
Conclusions: Urbanization process may increase the incidence of NRIDs but constrained by COVID-19. Certain measures should be taken to prevent and control the effects by urbanization process, such as good natural environment with less population density, ecological environment with good air quality, promoted hand hygiene, mask wearing, keeping interpersonal distance, vaccination, media publicity for NRIDs' prevention and control.

1. Introduction

World Health Statistics 2023 by world health organization showed that 18% of global deaths were caused by communicable diseases [1]. Respiratory infections remained the world's most deadly communicable disease as the 4th leading cause of death, claiming 2.6 million lives in 2019 [2]. Even though the number of deaths due to respiratory infections has gone down since 2000, multiple emerging respiratory infections led to great harm at an historically unprecedented rate within recent years, including severe acute respiratory syndrome (SARS) in 2003, H1N1 influenza A(H1N1) in 2009, middle east respiratory syndrome (MERS) in 2012 and coronavirus disease 2019 (COVID-19) in 2019. Acute respiratory infection (ARI) is the leading cause of child mortality among all infectious diseases, leading to one in every seven deaths among children under five years in 2019 [3].

Many studies indicate that urbanization is the lead cause on emerging and resurging infectious diseases [4,5]. In the modern world of large inter-connected urban populations and rapid transport, the risk of global transmission of new infectious diseases is high [6]. It was predicted that the world's urban population would almost reach 6.3 billion in 2050, and the increase would come mainly from developing countries [7]. As one of the largest developing countries, China's urbanization has been a momentous event attracting worldwide attention [8,9], with the urban population increased rapidly from 151.5 million (17.2 % of total population) in 1973 to 842.9 million (60.3 % of total population) in 2018 [10], and an additional increase of 255 million by 2050 estimated [11]. At learning of western urbanization development, centralization, sub-urbanization, counter-urbanization and re-urbanization are the main phases in the life cycle of metropolis [12], and innovative urbanization's concept and implementation is put forward. Tongzhou district acts as the Beijing municipal administrative center with the new urbanization strategy implementation, developed with new, green, eco-friendly and livable urban area as a demonstration zone of innovation-driven [13]. The new urbanization will be generated under rapid socioeconomic development from 2016 to 2035, the large influx of population due to relieving Beijing of functions non-essential to its role as China's capital, and innovation-driven urban area building-up. Urbanization may have the effects on the association between the NRIDs incidence and other variables, such as air pollutants. Multiple studies revealed that increased population and economical urbanization were the main driving factors for the decline of air quality [14–16]. On the other hand, studies also indicated efficiency of resources' utilization and upgrading of industrial structure during urbanization process improved the pollution emissions [17–21].

Multiple studies discovered the prevention and control of COVID-19 had effects on other notifiable infectious diseases (NIDs). In the meantime, COVID-19 pandemic was much more than a health crisis, and it created one of the most significant economic shocks of the last century [22]. The recovery has been uneven, with developing countries in particular lagging and more likely to suffer long term scarring effects in health, society, economy and politics, and COVID-19 may jeopardize the process of urbanization. Besides, many studies disclosed the impact of COVID-19 on the notification of other NIDs, incidence of NIDs decreased obviously during COVID-19 period [23–26]. Respiratory transmissible infections decreased under COVID-19 period, to the opposite trend against the period prior to that.

Hence, this surveillance study was conducted to analyze the impact of urbanization on epidemiological characteristics of notifiable respiratory infectious diseases (NRIDs) in Tongzhou district of Beijing during 2014–2022 in order to provide reference for prevention and control priorities of respiratory infectious diseases during the innovative urbanization process in China.

2. Methods

2.1. Data source

Tongzhou located in southeast of Beijing, at 39°36 '−40 °02′ north latitude, 116° 32 '−116 °56′ east longitude, with land area as of 906 square kilometers (Fig. 1). The entire area landed with flat terrain and an average altitude of 20 m and climate is in the warm zone continental semi-wet monsoon climate zone [1,27].

This was a surveillance study. The study subjects were all cases of NRIDs occurred during 2014–2022, and data about the NRIDs patients were obtained from the National Notifiable Disease Reporting System (NNDRS) of the Chinese Center for Disease Control and Prevention (CDC). CDC passively obtained the data on NIDs from all medical and clinical sites and reported all the NIDs within the required timeframe and formatted template by National Health and Family Planning Commission of the People's Republic of China. Demographic data were from Tongzhou Statistical Yearbook released by the Tongzhou Bureau of Statistics. Urbanization data in Tongzhou district was gathered from the Tongzhou Statistical Yearbook, Statistical Bulletin of Tongzhou National Economic and Social Development. The study was approved by the Ethics Committee of Beijing Tongzhou Center for Diseases Prevention and Control, with the ethical approval reference number as of 202111-1.

Fig. 1. Location of the study area.

2.2. Definition of respiratory infectious diseases within NIDs

Reported NRIDs included pertussis, measles, human infection with highly pathogenic avian influenza, COVID-19, scarlet fever, influenza, mumps, rubella and etc. Age and sex were collected.

2.3. Definition of urbanization

Referring the published comprehensive measurement index system, the comprehensive indicator of urbanization (CIU) were constructed at basis of population urbanization (proportion of urban population, urban population, registered urban unemployment rate, residence density), economic urbanization (per capita GDP, per capital gross industrial output value, proportion of 1st, 2nd and 3rd industry structures, proportion of tax structure of 1st, 2nd and 3rd industries, Engel coefficient, reduction rate of energy consumption per 10 000 yuan of GDP), land urbanization (per capita green areas, per capita park green areas, total highway mileage, per capita living space of urban residents, per capita living space), social urbanization (per capita electricity consumption, per capita electricity consumption of urban residents, number of doctors per 10 000, number of hospital beds per 10 000), and environmental urbanization (yearly percentage of sewage disposed, innocuous disposal rate of domestic garbage, yearly concentration of fine particulate matter 2.5, accumulative improvement rate of river water quality, forest coverage rate, greenery coverage in urban areas, mean value of ambient noise, mean value of road traffic noise), and weight of each was determined by the entropy value method [28]. In the measurement of the comprehensive indicator system, the method of determining the weight of the indicator was objective empowerment methods, and the weight was determined implementing entropy method, at basis of the amount of information provided by each indicator. It was generally believed that the higher the information entropy value, the more balanced the system structure, the smaller the variation, or the slower the change; to the contrast, the lower the information entropy, the more uneven the system structure, the greater the difference, or the faster the change. Therefore, the weight could be calculated based on the size of the entropy value, that is, the degree of variation of the various index values. The main steps were as follows.

If the larger index value brings more benefits to the development of the system, positive index calculation method is used: $X'_{ij}=(X_{ij}-min\{X_j\})/(\max\{X_j\}-min\{X_j\})$;

If the smaller index value brings more benefits to the development of the system, negative index calculation method is used: $X'_{ij}=(\max\{X_j\}-X_{ij})/(\max\{X_j\}-\min\{X_j\})$.

Proportion of the index value of item j in year i: $Y_{ij} = X'_{ij} / \sum_{i=1}^{m} X'ij$;

Information entropy index: $e_j = -k \sum_{i=1}^{m} (Yij \times \ln Yij)$, and when if $k = 1/\ln(m)$, there will be $0 \leq ej \leq 1$;

Redundancy of information entropy: $d_j=1-e_j$

Weight of index: $w_i = d_i / \sum_{j=1}^{n} dj$;

Evaluation score of individual index: $S_{ij} = w_i \times X'_{ij}$

Score of aggregation *level in year i:* $Si = \sum_{i=1, j=1}^{n} Sij$;

where Xij denotes the index value of item j in year i, min{Xj} and max{Xj} represent the minimum and maximum index of item j within all years respectively, m is the number of year, and n is the number of index.

2.4. Statistical analysis

NRIDs incidence rates per 100 000 by age groups, sex, incident years during 2014–2022, and the stage of urbanization of Tongzhou district were compared with χ^2 method.

The average incidence rates of NRIDs among three urbanization periods were compared by using rate difference and rate ratio (RR) with Wilson method for their 95 % confidence interval (CI).

Considering the large sample size, the binomial distribution of NRIDs' incidence was similar to normal distribution and Wilson method was taken for 95 % CI.

$$N = n + u$$

$$p = n/N$$

$$S = \left(\left(P_a^2 \Big/ 2N \pm Z_a \Big/ 2N\sqrt{4}N(1-P) + Z_a^2\right)\left(1 + Z_a^2 \Big/ N\right)\right.$$

where n denotes the positive NRIDs case number, u for the negative NRIDs case number, and N for the total population number, p represents the incidence rate of NRIDs, and 95%CI(S) sets the a as 0.05, Z_a is 1.96.

The association between the annual incidence rate of NRIDs and the urbanization indicators was calculated by Pearson correlation analysis and generalized linear model (GLM).

According to the temporal characteristics of NRIDs' distribution, Joinpoint (version 5.0.2, developed by National Cancer Institute) was used for annual percent change (APC) and average annual percent change (AAPC) of NRIDs incidence, to provide the trend of NRIDs during 2014–2022. The Joinpoint regression model was constructed in grid search method via annual aged-adjusted incidence rate of NRIDs and standard error through an uncorrelated error model and implementing the log-linear model as [29]:

$$E[y|x] = e^{\beta 0+\beta 1x+\delta 1(x-\tau 1)+\ldots+\delta k(x-\tau k)}$$

$$e = \lim(1 + 1/n\widehat{)}n,$$

where k denotes number of turning points, τ_k for the uncharted number of turning points, and β_0 as the constant, β_1 for the regression coefficient, δ_k represent the regression coefficient of the segment k.

When APC>0, it means the incidence of NRIDs increased, and it turned out the contrast trend if APC<0.

All statistical analyses were performed using STATA 17 (Stata Corp LP, College Station, TX, United States). A two-sided $P < 0.05$ was considered statistically significant.

Table 1
Incidence of national respiratory infectious diseases during 2014–2022 in Tongzhou district, Beijing.

Variable	No. of total populations	No. of NRIDs cases	Incidence rate (1/100 000)	P	No of deaths in NRIDs	Mortality rate (1/100 000)	P
Age group							
<15 years	1720000	35225	2047.97	<0.001	6	0.35	<0.001
15–65 years	11326000	32191	284.22		11	0.10	
≥65 years	1608000	5200	323.38		64	3.98	
Sex							
Male	7672000	37747	492.01	0.044	67	0.87	<0.001
Female	6982000	34869	499.41		14	0.20	
Total	14654000	72616	495.54	–	81	0.55	–

Note: Chi-square test used for the statistical analysis.
The differences of NRIDs incidence rate and mortality rate were significant between any two of age groups.

3. Results

3.1. NRIDs overview

In total, 72616 NRIDs cases had been reported during 2014–2022 with 51.98 % (37747) of male cases (Table 1). The NRIDs average incidence rate was 495.54/100 000 between 2014 and 2022 and the incidence rate of NRIDs was 492.01/100 000 in males, lower than that in female (P = 0.044). The incidence rate of NRIDs in the population under 15 years old was 2047.97/100 000, significantly higher than those in the other two age groups (both P < 0.001). Between 2014 and 2022, the mortality rate of NRIDs was 0.55/100 000 and it was the highest in the elders (3.98/100 000).

NRIDs incidence rate ascended from 168.57/100 000 in the year of 2014 and reached the peak as of 1725.23/100 000 in the year of 2019 with a slight reversal in 2015 as of 116.21/100 000 (Fig. 2A), showing the APC of 74.52 % during 2014–2015 (P < 0.05). The incidence rate of NRIDs continuously declined in the years of 2020 and 2021 since COVID-19 outbreak and rose to 659.14/100 000 in 2022 with the APC of −29.89 % during 2019–2022 (P = 0.041). The incidence rate of NRIDs in males and females followed the same trend as the total population and reached their own peaks at 1616.45/100 000 and 1844.55/100 000 in the year of 2019, respectively (Fig. 2B). Compared to the groups of 15–65 years and ≥65 years, the incidence rate of NRIDs in the group of <15 years revealed a larger fluctuations during all the period, peaking in the year of 2019 (9218.65/100 000 in the group of <15 years, 791.84/100 000 in the group of 15–65 years and 575.63/100 000 in the group of ≥65 years) in Fig. 2C.

3.2. CIU and the relation to NRIDs incidence rate

The CIU value increased along with the year from 28.96 to 74.17 (Fig. 3A and Supplemental Table 1). The proportion of environment urbanization was the highest among the composition of CIU. No relationship was observed between the CIU and NRIDs incidence rate (r = 0.45, P = 0.224) by Pearson correlation analysis and (β = 12.7; 95 % CI -9.9, 35.4) by generalized linear model during 2014–2022 (Fig. 3B and Table 3). As the NRIDs incidence rate decreased from 2019 due to COVID-19, this relationship was estimated after removing the data during 2020–2022. A strong correlation was observed with r = 0.95 (P = 0.004) by Pearson correlation analysis. The NRIDs incidence rate increased along with the increase of CIU (β = 43.4; 95 % CI 22.9, 63.9). As the composition of CIU, population urbanization, economy urbanization and environment urbanization were associated with the NRIDs incidence rate (all P < 0.05, Table 3).

3.3. NRIDs under different urbanization stages

According to the comprehensive indicator of urbanization and the impact of COVID-19 pandemic, the urbanization process of Tongzhou district was divided to pre-urbanization (2014–2016), urbanization without COVID-19 (2017–2019) and urbanization with COVID-19 (2020–2022).

The incidence rate of NRIDs was 929.94/100 000 at the urbanization period with COVID-19 pandemic, higher than those at the pre-urbanization period and at the urbanization period without COVID-19 pandemic (153.49/100 000 and 370.65/100 000) with the RRs of 6.06 (95 % CI 5.90−6.22) and 2.41 (95 % CI 2.35−2.48) in Table 4 and Table 5. Significant differences of NRIDs incidence rate were observed among the different age groups. For the patients aged <15 years, the incidence rate of NRIDs revealed a very sharp rise at the urbanization period without COVID-19 pandemic, in comparison with the incidence under pre-urbanization period (RR = 7.93, 95 % CI 7.63−8.24), and dropped off to the similar level as of pre-urbanization period when COVID-19 pandemic spread. For the patients aged 15−65 years and ≥65 years, a moderate increase of NRIDs incidence rate was observed at the urbanization period without COVID-19 pandemic (RR = 5.01, 95 % CI 4.91−5.21; RR = 2.25, 95 % CI 2.00−2.44) in comparison of pre-urbanization. However, they begun to decrease during the pandemic of COVID-19, still higher than those at pre-urbanization period. The rate difference of

Table 2
Incidence of national respiratory infectious diseases during 2014–2022 in Tongzhou district, Beijing.

Variable	During 2014–2019(Pre-Pandemic)			During 2020–2022(Pandemic)			
	No. of total populations	No. of NRIDs cases	Incidence rate (1/100 000)	No. of total populations	No. of NRIDs cases	Incidence rate (1/100 000)	P
Age group							
<15 years	1036000	30012	2896.91	684000	5213	762.13	< 0.001
15−65 years	7132000	18994	266.32	4194000	13197	314.66	< 0.001
≥65 years	960000	3128	325.83	648000	2072	319.75	0.505
Sex							
Male	4768000	26542	556.67	2904000	11205	385.84	< 0.001
Female	4360000	25592	586.97	2622000	9277	353.81	
Total	9128000	52134	571.14	5526000	20482	370.65	< 0.001

Note: Chi-square test used for the statistical analysis.

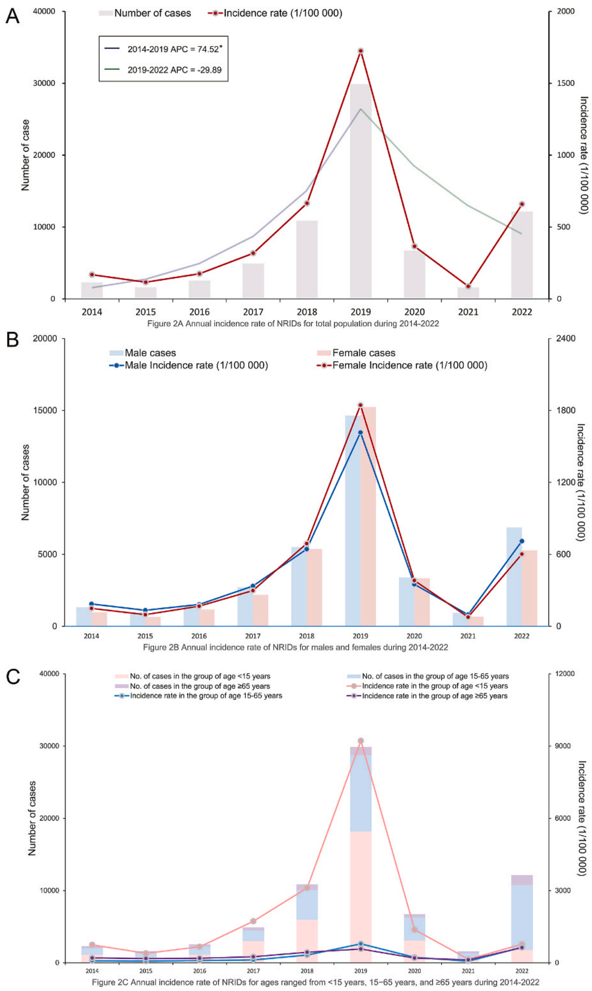

Fig. 2. Annual incidence and incidence rate on notifiable respiratory infectious diseases for total population during 2014−2022. (A) Annual incidence rate of NRIDs for total population (B) Annual incidence rate of NRIDs for males and females (C) Annual incidence rate of NRIDs for ages ranged from <15 years, 15−65 years, and ≥65 years.

NRIDs was larger in female than in male during the urbanization process with the comparison between pre-urbanization and urbanization without COVID-19 period (RR = 5.31, 95%CI 5.13−5.50 in male vs. RR = 7.04, 95 % CI 6.77−7.33 in female).

3.4. *NRIDs under different stages between pre-pandemic period and pandemic period*

The stratification analysis was performed between the pre-pandemic period (2014–2019) and pandemic (2020–2022) for the incidence rate of NRIDs.

The incidence rate of NRIDs was 571.14/100 000 at pre-pandemic period, noticeably higher than the pandemic period (370.65/100 000), and the trend was displayed comparing the incidence rate of NRIDs in males and females. Significant differences of NRIDs incidence rate were observed among <15 years and 15−65 years, and no statistical differences detected among the elderly (≥65 years) in Table 2.

4. Discussion

Tongzhou district has experienced a rapid urbanization due to the overall development planning of Beijing. This gave us an opportunity to evaluate the changes in respiratory infectious diseases during rapid urbanization. This study indicated NRIDs incidence rate increased along with the urbanization process in Tongzhou district, Beijing during 2014–2022, which was weakened by the COVID-19 pandemic.

The urbanization process caused more serious impacts on the population aged less than 15 years in comparison with other age groups. This may be led by the relatively weaker immune system and resistance of children, intensive contact between the adolescents

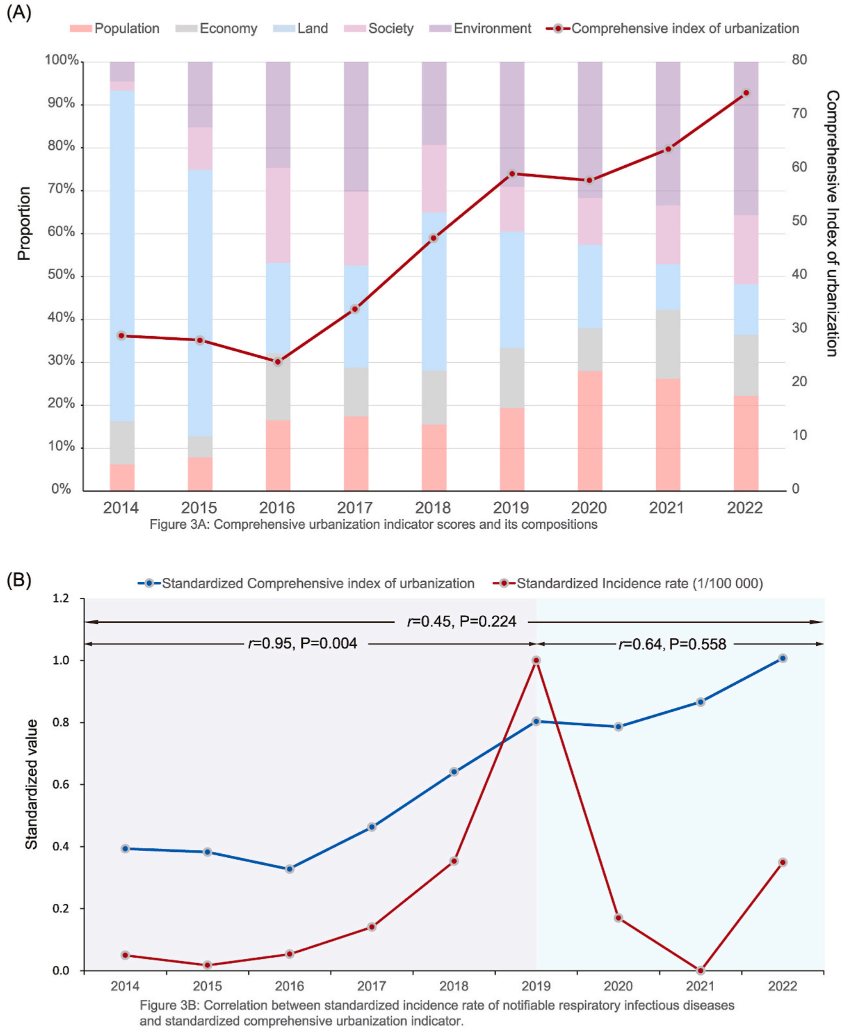

Fig. 3. Correlation between standardized incidence rate of notifiable respiratory infectious diseases and standardized comprehensive urbanization indicator. (A) Comprehensive urbanization indicator scores and its compositions (B) Correlation between standardized incidence rate of notifiable respiratory infectious diseases and standardized comprehensive urbanization indicator.

Table 3
The association between NRIDs incidence rate and urbanization indicators by generalized linear model.

Urbanization indicator	During 2014–2022			During 2014–2019		
	β	95 % CI	P	β	95 % CI	P
Comprehensive indicator of urbanization	12.7	−9.9, 35.4	0.225	43.4	22.9, 63.9	0.004[a]
Population	25.0	−44.4, 94.5	0.423	147.6	74.0, 221.3	0.005[a]
Economy	75.3	−50.1, 200.7	0.199	213.8	82.8, 344.7	0.011[a]
Land	6.0	−80.2, 92.3	0.873	−2.7	−146.9, 141.6	0.961
Society	45.4	−88.0, 178.9	0.447	107.1	−159.6, 373.8	0.327
Environment	23.3	−25.5, 72.1	0.296	91.9	29.4, 154.4	0.015[a]

Note: GLM used for the statistical analysis.
[a] means the index indicator with the statistical significance.

at schooling, and lack of self-health awareness of themselves. Multiple studies indicated similar conclusion that immunity is relatively weak, and systemic development status are more likely to be infected [30].

This study revealed the complex and comprehensive urbanization factors' influence on the incidence rate of NRIDs. It was disclosed that the factors of population and economy were the leading causes on the increased NRIDs incidence rate, and the factor of environment played an important role into this as well. In other word, considering the construction of CIU, more increasingly NRIDs

Table 4
Comparison of incidence rate of national respiratory infectious diseases among three urbanization stages.

Variable	Pre-urbanization period			Urbanization period without COVID-19			Urbanization period under COVID-19			P value
	No. of cases	Incidence rate (/100 000)	P	No. of cases	Incidence rate (/100 000)	P	No. of cases	Incidence rate (/100 000)	P	
Age group										
<15 years	2845	605.32	<0.001[a,b,c]	27167	4799.82	<0.001[a,b]	5213	762.13	<0.001[a,b]	<0.001[d,e,f]
15−65 years	2824	84.88		16170	424.97		13197	314.66		<0.001[d,e,f]
≥65 years	805	191.21		2323	430.98		2072	319.75		<0.001[d,e,f]
Sex										
Male	3680	167.42	<0.001	22862	889.57	<0.001	11205	385.85	<0.001	<0.001[d,e,f]
Female	2794	138.32		22798	974.27		9277	353.81		<0.001[d,e,f]
Total	6474	153.49		45660	929.94		20482	370.65		<0.001[d,e,f]

Note: Chi-square test used for the statistical analysis.
[a] means the significant difference between the groups of <15 years and 15−65 years.
[b] means the significant difference between the groups of <15 years and ≥65 years.
[c] means the significant difference between the groups of 15–65 years and ≥65 years.
[d] means the significant difference between the stages of Pre-urbanization period and Urbanization period without COVID-19.
[e] means the significant difference between the stages of Pre-urbanization period and Urbanization period with COVID-19.
[f] means the significant difference between the stages of Urbanization periods with and without COVID-19.For the pairwise comparison between any two groups, α was set at 0.017.

Table 5
The difference of NRIDs incidence among the three-urbanization process in Tongzhou.

Urbanization stage	Risk difference (95 % CI) (/100 000)	Risk ratio (95 % CI)
Urbanization without COVID-19 pandemic vs. Pre-urbanization	776 (767–786)	6.06 (5.90–6.22)
<15 years	4195 (4135–4254)	7.93 (7.63–8.24)
15−65 years	340 (333–347)	5.01 (4.91–5.21)
≥65 years	240 (218–244)	2.25 (2.00–2.44)
Male	722 (709–735)	5.31 (5.13–5.50)
Female	836 (822–850)	7.04 (6.77–7.33)
Urbanization with COVID-19 pandemic vs. without COVID-19 pandemic	559 (549–569)	2.51 (2.47–2.55)
<15 years	4038 (3978–4098)	6.30 (6.12–6.49)
15−65 years	110 (102–119)	1.35 (1.32–1.38)
≥65 years	(89−133)	1.35 (1.27–1.43)
Male	504 (498–517)	2.31 (2.25–2.36)
Female	620 (606–635)	2.75 (2.69–2.82)
Urbanization with COVID-19 pandemic vs. Pre-urbanization	217 (211–223)	2.41 (2.35–2.48)
<15 years	157 (127–187)	1.26 (1.20–1.31)
15−65 years	230 (224–236)	3.71 (3.56–3.86)
≥65 years	129 (109–148)	1.67 (1.54–1.81)
Male	218 (209–227)	2.30 (2.22–2.39)
Female	216 (207–224)	2.56 (2.45–2.67)

Note: Wilson rank test used for the statistical analysis.

incidence may be caused by more urban population, high-density population, per capital GDP's rising, air pollution, and destruction of the ecological environment. Gurram et al. [31] evaluated the spatial relationship between epidemiological-linked cases, epidemiological-unlinked cases, and imported cases in Singapore, showing that high-urbanization and high-density population might be the risk factors for SARS-CoV-2 transmission. Urbanization had a complex impact on influenza transmission patterns, including more rapid transmission along with the development of economy [32]. Yang et al. concluded that the difference in influenza epidemic intensity in northern China was partly due to urbanization process and transportation scale [33]. An epidemiological survey of diphtheria in the Republic of Haiti reported a positive correlation between diphtheria incidence and urban population proportion and sanitation density [34]. Vlahov et al. indicated traffic, housing, food, water, sewage issue into environment caused by the rapid and unbalanced economy development may lead to high burden to the health system, then accelerated the transmission of infectious diseases [35]. The urbanization accelerated carbon emissions, causing more serious air pollution [36], which increased the risk of respiratory infectious diseases [37–39].

The urbanization might promote the spread of COVID-19 due to high population density and a developed transportation system [31,40–42]. However, multiple studies indicated the COVID-19 pandemic averted the epidemic trend of NRIDs [43–49]. The prevention and control measures against COVID-19 had a manifest reducing effect on the incidence of infectious diseases with different transmission routes [50,51], which was also observed in our study. This study suggested the similarity on the correlation in comparing the NRIDs incidence during urbanization without COVID-19 and under COVID-19. Moreover, NRIDs incidence was still higher at urbanization under COVID-19 stage than the pre-urbanization stage. It illuminates urbanization process indeed accelerated the spreading of NRIDs.

This study was an ecological study without "suggesting" causal relationships since no control group set. The limitations included a potential reduction of in healthcare presentations by individuals for fear of exposure to patients with COVID-19, lack of healthcare utilization and access due to traveling limitation or quarantine policy, and increased uptake of telehealth, which might lead to less cases. COVID-19 triggered more attention on public health and willingness on vaccination. The number of vaccinated people and the vaccine efficiency had a positive effect on reducing the incidence of COVID-19 [52,53], and influenza vaccination was also an effective way to prevent influenza [54], indicating there would be herd immunity to influenza A (H1N1) when a certain percentage of the population was vaccinated. Besides, mass COVID-19 cases might not be fully captured as the outbreak of COVID-19 occurred within a short duration in the last month of 2022. In addition, no COVID-19 cases were reported until the year of 2020, which may be caused by the lag effects of non-pharmacological intervention measures into the mortality and morbidity of NRIDs.

5. Conclusion

Evidence of our analysis verified the fact that the urbanization increased the possibility of NRIDs' transmission among the population, especially in population less than 15 years old. The implementation of public health measures on COVID-19 might have contributed to a decrease in NRIDs incidence rate during the urbanization process. While it is of complexity of the impact of urbanization on respiratory infectious diseases. Some useful public health measures [55–60] can be proposed to reduce the risk of respiratory infectious diseases, such as good natural environment with less population density, ecological environment with good air quality, promoted hand hygiene, mask wearing, keeping interpersonal distance, vaccination, mask-wearing, media publicity for NIRDs' prevention and control.

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Ethics declarations

The study was reviewed and approved by Ethics Committee of Beijing Tongzhou Center for Diseases Prevention and Control with the approval number 202111-1, exempting from informed consent because all cases for this study were the notifiable cases.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Chang-Yu Guo: Writing – original draft, Formal analysis, Data curation. **Wan-Xue Zhang:** Validation. **Yi-Guo Zhou:** Validation. **Shan-Shan Zhang:** Validation. **Lu Xi:** Investigation, Data curation. **Ran-Ran Zheng:** Formal analysis. **Juan Du:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Data curation. **Jianming Zhang:** Supervision, Conceptualization. **Yan Cui:** Supervision, Conceptualization. **Qing-Bin Lu:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29987.

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