JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Coronavirus Pandemic

COVID-19 public health measures reduce the incidence of respiratory infectious diseases

Zhenzhou Wan[1#], Yulin Wang[2#], Jiao Liang[3], Yueqin Cao[1], Renfei Lu[4], Chiyu Zhang[5]

[1] *Taizhou Fourth People's Hospital, Taizhou, China*
[2] *Jiangsu Agri-Animal Husbandry Vocational College, Taizhou, China*
[3] *Shaanxi Provincial People's Hospital, Xi'an, China*
[4] *Clinical Laboratory, Nantong Third Hospital Affiliated to Nantong University, Nantong, China*
[5] *Shanghai Public Health Clinical Center, Fudan University, Shanghai, China*

# Authors contributed equally to this work.

Abstract

Background: Children and the elderly are two special subpopulations for coronavirus disease 2019 (COVID-19) and respiratory tract infections (RTIs). The study aimed to evaluate the effect of COVID-19 public health measures on the burden of RTIs in China by performing a two-center investigation.

Methods: The electronic medical records of all inpatients in departments of pediatrics and respiratory medicine of Taizhou Fourth People's Hospital (Taizhou, China) and Shaanxi Provincial People's Hospital (Xi'an, China) during January 1, 2019 to June 30, 2021 were analyzed. A total of 18,084 child inpatients and 14,802 adult inpatients were included.

Results: The vast majority (88.3%-90.6%) of the adult inpatients were the elderly, aged over 50 years. The numbers of child and adult (elderly) inpatients, and the proportions of RTI-associated diseases substantially decreased during COVID-19 pandemic (2020-2021) compared to that before the pandemic (2019) in Taizhou and Xi'an. A significantly higher proportion of LRTI-associated diseases was observed in elderly female inpatients (53.4-55.6%) than elderly male inpatients (34.3-41.5%) ($p < 0.001$) in spite of more male inpatients than female inpatients (1.94-1.95:1).

Conclusions: COVID-19-related interventions provide an additional beneficial effect on reduction of RTI-associated diseases in both children and the elderly.

Key words: SARS-CoV-2; COVID-19; respiratory tract infections (RTIs); children; the elderly; intervention measures; gender.

J Infect Dev Ctries 2022; 16(4):600-603. doi:10.3855/jidc.15898

(Received 05 October 2021 – Accepted 22 December 2021)

Introduction

Since late 2019, coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in over 267.3 million infections and 5.28 million deaths globally. The emergency use of several COVID-19 vaccines did not completely stop the transmission of newly generated SARS-CoV-2 variants that have caused several waves of COVID-19 in different countries. Currently, the "Omicron Variant" that can cause vaccine-breakthrough infections has rapidly spread across the world and triggered a new wave of the pandemic [1,2].

Respiratory tract infections (RTIs) are a leading cause of morbidity and mortality globally [3-5]. Children and the elderly are two special subpopulations for COVID-19 and RTIs [4-7]. Children are less susceptible to COVID-19 with the lowest morbidity and mortality [6], but are highly vulnerable to RTIs (e.g. respiratory syncytial virus (RSV) and rhinovirus infections) [8]. Whereas, the elderly are not only a major high-risk group for COVID-19 with the highest mortality, but also vulnerable to RTIs.

Public health measures, including wearing facemask, social distancing, and quarantine, are effective strategies to stop the spread of SARS-CoV-2, and play a vital role in the control of the pandemic [9-11]. Aggressive public health measures were implemented nationwide in China since late January 2020 and showed good results in the prevention and control of the COVID-19 pandemic. Public health measures were previously reported to reduce the incidence of respiratory viral infection in Australia, Brazil, France, Finland, Israel, Japan, Korea, USA, and Singapore [12-21], suggesting that COVID-19 public

health measures have a beneficial role in the containment of non-SARS-CoV-2 respiratory pathogens. Here, we aimed to evaluate the effect of COVID-19 public health measures on frequency and burden of RTI-associated illnesses in children and adults in Taizhou and Xi'an cities of China.

Methods

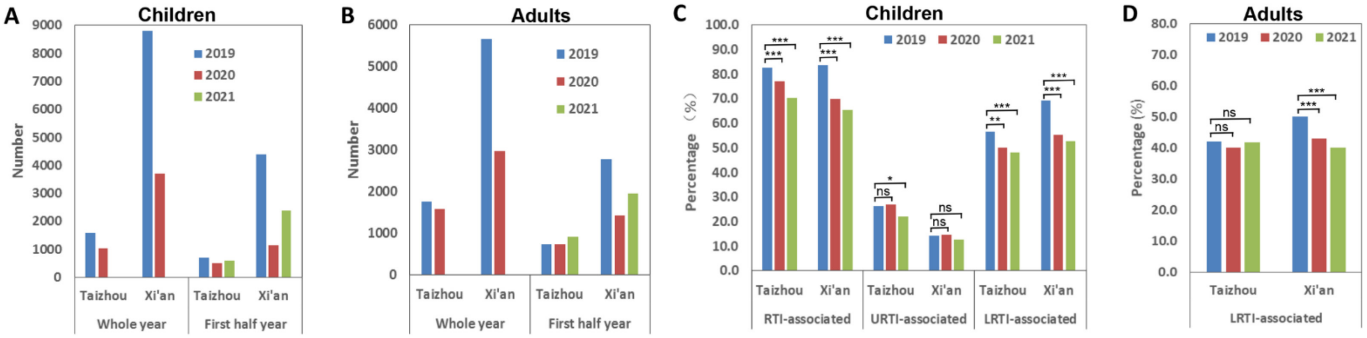
Public health measures have less effect on hospital admission. To investigate the effect of public health measures on RTIs in children and adults, we analyzed the electronic medical records of all inpatients in departments of pediatrics and respiratory medicine of Taizhou Fourth People's Hospital (Taizhou) and Shaanxi Provincial People's Hospital (Xi'an) between January 1, 2019 and June 30, 2021. The study was approved by Nantong Third Hospital Ethics Committee (E2020003). Overall, data for 3,220 child inpatients and 4,235 adult inpatients in Taizhou, and 14,864 child inpatients and 10,567 adult inpatients in Xi'an was included in the study. The ratios of boys to girls were 1.31:1 and 1.23:1, and the ratios of male to female adult inpatients were 1.94:1 and 1.95:1 in Taizhou and Xi'an, respectively. The age of children and adult inpatients ranged from two months to 16 years old (median 5) and 15 to 99 years (median 73), respectively, in Taizhou city. Meanwhile the age of children and adult inpatients in Xi'an ranged from one month to 16 years old (median 3) and 13 to 100 years old (median 68), respectively. About 66.4% and 80.7% of child inpatients were younger than 6 years old in Taizhou and Xi'an, respectively (Supplementary Figure 1). The vast majority of the adult inpatients were elderly, aged over 50 years, in both cities (90.6% in Taizhou and 88.3% in Xi'an) (Supplementary Figure 1). No significant difference was observed in the age distribution of child and adult inpatients between Taizhou and Xi'an. Comparison of percentages was performed using chi-square test with a p value of 0.05.

Results

An obvious decrease (9.4%-58%) in number of child and adult inpatients was observed in both cities (especially in Xi'an) in 2020 compared to 2019, and a rebound was observed in 2021 (the first half year) (Figure 1A and B). The most commonly diagnosed diseases were upper respiratory tract infections (URTIs) (22.1%), acute bronchitis (20.7%), and bronchopneumonia (20.1%) in child inpatients, and chronic obstructive pulmonary disease (COPD) (30.0%) and pneumonia (29.2%) in adult inpatients in Taizhou, and lobar pneumonia (45.1%), bronchitis (9.2%), and amygdalitis (8.8%) in child inpatients and pneumonia (including concurrent pneumonia) (29.5%) and COPD (19.3%) in adult inpatients in Xi'an.

To evaluate the effect of COVID-19 public health measures on the burden of RTIs in the two cities, we analyzed RTI-associated diseases. The percentage of RTI-associated diseases significantly decreased in 2020 and 2021 (during COVID-19 pandemic) compared to that in 2019 (before COVID-19 pandemic) in child inpatients in both cities (77.0% and 70.2% vs. 82.8% in Taizhou, 70.0% and 65.5% vs. 83.6% in Xi'an, respectively; $p < 0.001$ for all) (Figure 1C). This decrease was mainly contributed by the significant decrease in the incidence of lower RTI (LRTI)-associated diseases ($p < 0.01$ or 0.001), but not by upper RTI (URTI)-associated diseases (Figure 1C). Similar

Figure 1. The numbers of inpatients in departments of pediatrics and respiratory medicine in two hospitals in Taizhou and Xi'an cities.



(A) number of child inpatients, (B) number of adult inpatients, (C) Percentage of RTI-associated diseases in children, and (D) Percentage of RTI-associated diseases in adult inpatients. The electronic medical records were obtained from Taizhou Fourth People's Hospital (Taizhou, China) and Shaanxi Provincial People's Hospital (Xi'an, China) between January 2019 and June 2021. For comparing the trend of inpatient number from 2019 to 2021, the numbers in first half of each year was shown. Since URTIs of adults is not generally considered as a criterion for hospitalization, only LRTI-associated illnesses were analyzed for adult inpatients. The data (patient numbers and percentages) used in this figure are shown in Supplementary Table 1. Statistical analysis was performed by chi-square test. *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; ns, not significant.

decrease in percentage of LRTI-associated diseases during COVID-19 pandemic was also observed in adult inpatients, and this decrease was statistically significant in Xi'an ($p < 0.001$), but not significant in Taizhou (Figure 1D). Decreased numbers of child inpatients in pediatrics department and adult inpatients in department of respiratory medicine, as well as significantly decreased percentages of RTI-associated diseases clearly indicate that COVID-19-related intervention measures substantially reduced the incidence of respiratory infectious diseases.

In addition, higher proportion of RTI-associated diseases was observed in boy inpatients (80.0% and 80.2%) as compared to girl inpatients (77.2% and 76.3%) in Taizhou ($p = 0.057$) and Xi'an ($p < 0.001$), respectively (Figure 2). However, significantly higher proportion of LRTI-associated diseases was observed in female adult inpatients (53.4-55.6%) than male adult inpatients (34.3-41.5%) in both cities ($p < 0.001$). The reason for the gender difference in proportion of RTI-associated diseases between children and old adults is unclear.

Discussion

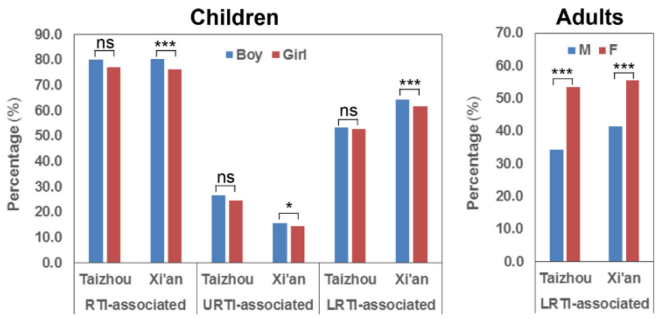
The elderly and children are vulnerable groups for RTIs, which are the major threat to their health and the foremost cause of deaths [3,5]. The elderly who have accumulated more RTIs and had longer-term exposure to polluted air and/or smoking, often had one or more comorbidities, which result in the worst COVID-19 clinical outcomes [6,7]. Like children, the elderly also have relatively weak immune system, and are vulnerable to RTIs [22]. Community/home transmissions might be the major route for RTIs among the elderly and children due to their relatively less outdoor activities. Simple public health measures such as facemask wearing are predicted to be effective in reducing community/home transmissions of RTIs among high-risk groups. Widespread implementation of public health measures during the COVID-19 pandemic provided an opportunity to see the potential effect of these measures on the incidence of RTIs among vulnerable groups.

Since late January 2020, wearing facemask and other interventions were practiced widely in almost all cities of China and showed excellent effect on the containment of COVID-19 [10,11]. Significant declines in the numbers of child inpatients in department of pediatrics and elderly inpatients in department of respiratory medicine, as well as the percentages of RTI-associated diseases were observed for at least one and a half years in two different cities of China, suggesting that the implementation of these measures also significantly reduced the burden of RTI-associated illnesses, even though the restrictions were somewhat relaxed in 2021. The beneficial impacts of COVID-19 public health interventions were also observed in some other countries, regardless of urban or rural location [12-21]. This implies that even though these measures are no longer required for containing COVID-19, they can be practiced to some extent to reduce the burden of other respiratory infections.

Gender-specific difference in the incidence rate of RTIs was previously reported in both children and the elderly, and boys/males appeared to have higher RTIs incidence rate than girls/females [5]. Consistently, we observed about twice as many male as female elderly inpatients in both cities, substantially higher than overall men-to-women ratio of 1.00-1.04:1 (National census of China 2021). However, significantly higher percentages of LRTI-associated diseases were observed in elderly women than elderly men regardless of before and during the pandemics. This phenomenon could not to be explained by the differences in the risk of community exposure to RTIs between elderly women and men, but might be involved in the physiological and immunological differences.

In summary, despite some inconvenience and discomfort, COVID-19-related interventions provide an additional benefit of reducing RTI-associated diseases in both the elderly and children.

Figure 2. Comparison of the percentages of RTI-associated diseases between male and female inpatients.



Ratios of boys to girls was 1.31:1 and 1.23:1 in Taizhou and Xi'an, respectively. The ratio of male to female adult inpatients were 1.94:1 and 1.95:1, respectively. The data used in figure 2 is shown in Supplementary Table 2. Statistical analysis was performed by chi-square test. *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; ns, not significant. M, male; F: female.

Acknowledgements

This work was supported by the grant from the Health Commission of Jiangsu Province, China (Z2019038) to ZW.

Authors' Contributions

CZ conceptualized the study. ZW, JL and YC collected the data. ZW, YW and CZ analyzed the data and produced the figures. CZ, ZW, YW and RL interpreted the data. CZ and ZW wrote the first draft.

References

1. Araf Y, Akter F, Tang YD, Fatemi R, Parvez MSA, Zheng C, Hossain MG (2022) Omicron variant of SARS-CoV-2: Genomics, transmissibility, and responses to current COVID-19 vaccines. J Med Virol 94: 1825-1832.
2. Tian D, Sun Y, Xu H, Ye Q (2022) The emergence and epidemic characteristics of the highly mutated SARS-CoV-2 Omicron variant. J Med Virol 94: 2376-2383.
3. Williams BG, Gouws E, Boschi-Pinto C, Bryce J, Dye C (2002) Estimates of world-wide distribution of child deaths from acute respiratory infections. Lancet Infect Dis 2: 25-32.
4. Jin X, Ren J, Li R, Gao Y, Zhang H, Li J, Zhang J, Wang X, Wang G (2021) Global burden of upper respiratory infections in 204 countries and territories from 1990 to 2019. E Clinical Medicine 37: 100986.
5. Ruan Z, Qi J, Qian ZM, Zhou M, Yang Y, Zhang S, Vaughn MG, LeBaige MH, Yin P, Lin H (2021) Disease burden and attributable risk factors of respiratory infections in China from 1990 to 2019. Lancet Reg Health West Pac 11: 100153.
6. Wu Z, McGoogan JM (2020) Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72,314 cases from the Chinese center for disease control and prevention. JAMA 323: 1239-1242.
7. Farshbafnadi M, Kamali Zonouzi S, Sabahi M, Dolatshahi M, Aarabi MH (2021) Aging & COVID-19 susceptibility, disease severity, and clinical outcomes: The role of entangled risk factors. Exp Gerontol 154: 111507.
8. Li Y, Fu X, Ma J, Zhang J, Hu Y, Dong W, Wan Z, Li Q, Kuang YQ, Lan K, Jin X, Wang JH, Zhang C (2019) Altered respiratory virome and serum cytokine profile associated with recurrent respiratory tract infections in children. Nat Commun 10: 2288.
9. Nussbaumer-Streit B, Mayr V, Dobrescu AI, Chapman A, Persad E, Klerings I, Wagner G, Siebert U, Christof C, Zachariah C, Gartlehner G (2020). Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. Cochrane Database Syst Rev 4: CD013574.
10. Pan A, Liu L, Wang C, Guo H, Hao X, Wang Q, Huang J, He N, Yu H, Lin X, Wei S, Wu T (2020) Association of public health interventions with the epidemiology of the COVID-19 outbreak in Wuhan, China. JAMA 323: 1915-1923.
11. Wilder-Smith A, Freedman DO (2020) Isolation, quarantine, social distancing, and community containment: Pivotal role for old-style public health measures in the novel coronavirus (2019-CoV) outbreak. J Travel Med 27: taaa020.
12. Chou R, Dana T, Jungbauer R, Weeks C, McDonagh MS (2020) Masks for prevention of respiratory virus infections, including SARS-CoV-2, in health care and community settings : A living rapid review. Ann Intern Med 173: 542-555.
13. Tan JY, Conceicao EP, Sim XYJ, Wee LEI, Aung MK, Venkatachalam I (2020) Public health measures during COVID-19 pandemic reduced hospital admissions for community respiratory viral infections. J Hosp Infect 106: 387-389.
14. Britton PN, Hu N, Saravanos G, Shrapnel J, Davis J, Snelling T, Dalby-Payne J, Kesson AM, Wood N, Macartney K, McCullagh C, Lingam R (2020) COVID-19 public health measures and respiratory syncytial virus. Lancet Child Adolesc Health 4: e42-e43.
15. Friedrich F, Ongaratto R, Scotta MC, Veras TN, Stein RT, Lumertz MS, Jones MH, Comaru T, Pinto LA (2021) Early impact of social distancing in response to coronavirus disease 2019 on hospitalizations for acute bronchiolitis in infants in Brazil. Clin Infect Dis 72: 2071-2075.
16. Lee H, Lee H, Song KH, Kim ES, Park JS, Jung J, Ahn S, Jeong EK, Park H, Kim HB (2021) Impact of public health interventions on seasonal influenza activity during the COVID-19 outbreak in Korea. Clin Infect Dis 73: e132-e140.
17. Nolen LD, Seeman S, Bruden D, Klejka J, Desnoyers C, Tiesinga J, Singleton R (2021) Impact of social distancing and travel restrictions on non-coronavirus disease 2019 (Non-COVID-19) respiratory hospital admissions in young children in rural Alaska. Clin Infect Dis 72: 2196-2198.
18. Yeoh DK, Foley DA, Minney-Smith CA, Martin AC, Mace AO, Sikazwe CT, Le H, Levy A, Blyth CC, Moore HC (2021) Impact of coronavirus disease 2019 public health measures on detections of influenza and respiratory syncytial virus in children during the 2020 Australian winter. Clin Infect Dis 72: 2199-2202.
19. Oster Y, Michael-Gayego A, Rivkin M, Levinson L, Wolf DG, Nir-Paz R (2020) Decreased prevalence rate of respiratory pathogens in hospitalized patients during the COVID-19 pandemic: Possible role for public health containment measures? Clin Microbiol Infect 27: 811-812.
20. Kuitunen I, Artama M, Makela L, Backman K, Heiskanen-Kosma T, Renko M (2020) Effect of social distancing due to the COVID-19 pandemic on the incidence of viral respiratory tract infections in children in Finland during early 2020. Pediatr Infect Dis J 39: e423-e427.
21. Angoulvant F, Ouldali N, Yang DD, Filser M, Gajdos V, Rybak A, Guedj R, Soussan-Banini V, Basmaci R, Lefevre-Utile A, Brun-Ney D, Beaujouan L, Skurnik D (2021) Coronavirus disease 2019 pandemic: Impact caused by school closure and national lockdown on pediatric visits and admissions for viral and nonviral infections - A time series analysis. Clin Infect Dis 72: 319-322.
22. Childs A, Zullo AR, Joyce NR, McConeghy KW, van Aalst R, Moyo P, Bosco E, Mor V, Gravenstein S (2019) The burden of respiratory infections among older adults in long-term care: A systematic review. BMC Geriatr 19: 210.

Corresponding author

Chiyu Zhang, PhD
Shanghai Public Health Clinical Center,
Fudan University, Shanghai 201508, China
Phone no: (+86) 15800781776
Fax: +86 21-5724 8769
zhangcy1999@hotmail.com

Conflict of interests: No conflict of interests is declared.

Annex – Supplementary Items

Supplementary Table 1. The data presented in Figure 1.

a. Patient numbers presented in Figure 1 A and 1 B.

Group	Year	Whole year (patient number)		First half year (patient number)	
		Taizhou	Xi'an	Taizhou	Xi'an
Children	2019	1593	8792	701	4404
	2020	1046	3696	497	1143
	2021			581	2376
Adults	2019	1743	5652	736	2779
	2020	1580	2969	730	1416
	2021			912	1946

b. Percentages presented in Figure 1 C and 1 D.

Group	Year	RTI-associated (%)		URTI-associated (%)		LRTI-associated (%)	
		Taizhou	Xi'an	Taizhou	Xi'an	Taizhou	Xi'an
Children	2019	82.8	83.6	26.3	14.2	56.5	69.4
	2020	77.0	70.0	26.9	14.7	50.1	55.3
	2021	70.2	65.5	22.0	12.7	48.2	52.8
Adults	2019	NA	NA	NA	NA	42.1	50.1
	2020	NA	NA	NA	NA	40.1	42.9
	2021	NA	NA	NA	NA	41.9	40.1

NA: Not Applicable.

Supplementary Table 2. The data presented in Figure 2.

Group	RTI-associated (%)		URTI-associated (%)		LRTI-associated (%)	
	Taizhou	Xi'an	Taizhou	Xi'an	Taizhou	Xi'an
Boy	80.0	80.2	26.6	15.7	53.3	64.5
Girl	77.2	76.3	24.5	14.5	52.7	61.8
Male	NA	NA	NA	NA	34.3	41.5
Female	NA	NA	NA	NA	53.4	55.6

NA: Not Applicable.

Supplementary Figure 1. Age distribution of child and adult inpatients in Taizhou and Xi'an cities.