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'Dynamic zero-COVID' policy and viral clearance during an omicron wave in Tianjin, China: a city-wide retrospective observational study

Yahui Feng,[1] Hongxia Shao,[2] Xiaowen Gong,[1] Zhen Song,[1] Yan Xie,[3] Saibing Qi,[1] Lixia Shi,[2] Yu Hu,[1] Xueou Liu,[1] Xiaolong Liu,[2] Qiujin Shen,[1] Qi Wu,[4] Tao Cheng,[1] Wentao Jiang,[3] Junping Wu,[2] Junren Chen [1]

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YF, HS, XG, ZS and YX are joint first authors.
TC, WJ, JW and JC are joint senior authors.

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For numbered affiliations see end of article.

Correspondence to
Dr Junren Chen;
chenjunren@ihcams.ac.cn

ABSTRACT

Objective To report how the Chinese mainland battled its first omicron wave, which happened in Tianjin, a metropolis with 14 million residents. We also sought to better understand how clinical features affected the timing of viral clearance.

Design A retrospective study of the omicron wave in Tianjin between 8 January 2022 and 3 March 2022.

Setting Except for the first cases on 8 January, all the omicron cases were identified through PCR mass testing in the residential communities. Residential quarantine and serial PCR mass testing were dynamically adjusted according to the trends of new cases.

Participants All the 417 consecutive PCR-positive cases identified through mass screening of the entire city's 14 million residents. 45.3% of the cases were male, and the median age was 37 (range 0.3–90). 389 (93%) cases had complete data for analysing the correlation between clinical features and the timing of viral clearance.

Main outcome and measure Time to viral clearance.

Results Tianjin initiated the 'dynamic zero-COVID' policy very early, that is, when daily new case number was ≈0.4 cases per 1 000 000 residents. Daily new cases dropped to <5 after 3 February, and the number of affected residential subdivisions dropped to ≤2 after 13 February. 64% (267/417) of the cases had no or mild symptoms. The median interval from hospital admission to viral clearance was 10 days (range 3–28). An exploratory analysis identified a feature cluster associated with earlier viral clearance, with HRs of 3.56 (95% CI 1.66 to 7.63) and 3.15 (95% CI 1.68 to 5.91) in the training and validation sets, respectively.

Conclusions The 'dynamic zero-COVID' policy can suppress an omicron wave within a month. It might be possible to predict in advance which cases will require shorter periods of isolation based on their clinical features.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This article explains in depth how the 'dynamic zero-COVID' policy was executed in a mega-city when the omicron epidemic first started in China.
- ⇒ The entire city's 14 million residents followed the same public health rules to contain the domestic transmission of omicron, and all the PCR-positive cases were isolated and treated at one medical centre dedicated to COVID-19.
- ⇒ For each PCR-positive case, the clinical, laboratory and medication data were available; therefore, this article provides a fine-grained view of 'dynamic zero-COVID'.
- ⇒ A multidimensional approach to phenotypic analysis enabled the identification of a feature cluster associated with earlier viral clearance.
- ⇒ Due to differences in social systems and resources, the public health approach explained in this article might not extrapolate to other geographical regions.

INTRODUCTION

The 2022 Spring outbreak of the omicron variant of SARS-Cov-2 in Shanghai[1] has cast doubt on the validity of China's strict policy of 'dynamic zero-COVID'.[2] An alternative laxer approach—often referred to as 'living with COVID-19'— nonetheless are not without controversy and confusion.[3 4] Most importantly, despite the generally lower disease severity associated with the omicron variants,[5–7] 'living with COVID-19' may still lead to a considerable number of total excess deaths in the general population.[8–10] Until a transparent evaluation of the 'dynamic zero-COVID' policy becomes available, we believe that 'dynamic zero-COVID' should remain an option for non-pharmaceutical interventions during the COVID-19 pandemic. As of today, however, other than a handful of policy white papers,[11 12] the peer-reviewed literature contains little detail about how 'dynamic zero-COVID' has been implemented in China.

Tianjin, a centrally administered municipality with 16 city districts and 14 million residents, was the first city that experienced community spread of omicron on the Chinese mainland.[13] On 8 January 2022, three cases were diagnosed with COVID-19 in the city's Jinnan district through PCR tests in fever clinics (two cases) and caretaker pre-employment screening (one case). The three cases did not share itineraries in the prior 2 weeks. Sequence analysis of the first cases on 8 January indicated omicron BA.1.[14] A 'dynamic zero-COVID' strategy was initiated: Jinnan district was immediately put under quarantine, eight rounds of city-wide and district-wide PCR mass testing (turnaround time <24 hours) ensued between 9 January and 20 January, and residential quarantine as well as additional PCR mass testing were dynamically adjusted according to the trends of new cases. A total of 439 suspect cases were identified through 3 March, and all were admitted to the Haihe Hospital. PCR retesting at the Haihe Hospital confirmed 417 cases. On 24 February, the Tianjin Centers for Disease Control and Prevention (CDC) announced the identification of one domestic case of omicron BA.2 in Tianjin,[15] who was also admitted to the Haihe Hospital.

In this study initiated by the Tianjin Municipal Health Commission, we sought to examine how Tianjin battled an omicron wave under the 'dynamic zero-COVID' principle. We also report the result of an exploratory analysis on the relationship between clinical features and the timing of viral clearance.

METHODS

Definitions

A 'case' was defined as any PCR-positive person who was admitted to the Haihe Hospital and reconfirmed with another PCR. 'PCR positivity' was defined as cycle threshold (Ct) ≤40 according to the Haihe Hospital's self-designated standard during the study period. The Ct cut-off value was set to be high for strict containment of the virus. (Later, the Ct cut-off value was lowered to 35 on 14 March 2022, per an updated regulation issued by the National Health Commission of China.)

Clinical features within 3 days of Haihe admission were considered 'at admission'. 'Viral clearance' was defined as the first day of ≥2 consecutive negative PCRs spanning ≥24 hours at the Haihe Hospital.

An 'affected residential subdivision' was defined as a residential subdivision that was confirmed by the National Health Commission of China to have had ≥1 new PCR-positive case in the prior 2 weeks. In Tianjin, a typical residential subdivision contains ten to twenty apartment buildings with thousands of residents that are walled in together and with a handful of shared gates to the exterior. An affected residential subdivision was typically put under quarantine for 14 days. All residents in a newly affected residential subdivision underwent PCR mass testing every 1–3 days.

After 20 January 2022, district-wide PCR mass testing was 'dynamically adjusted' at the discretion of each city district; that is, additional PCR mass testing in separate city districts was conducted at varying intervals (typically 3–14 days) determined by the individual districts.

Study population

All the 417 consecutive cases were included in this study. All the cases were first hospitalised at the Haihe Hospital and then—after viral clearance—transferred to the Tianjin First Central Hospital (TFCH) to recover. For the modelling effort to identify a feature cluster that was associated with earlier viral clearance, analysis was limited to the subset of 389 cases (93%) who had complete data. The flow diagram is available in online supplemental file 1.

Data acquisition

The clinical data were extracted from the electronic health records. The number of affected residential subdivisions was updated daily by the National Health Commission of China. The Ct values in the community PCR screenings were ascertained from the Tianjin CDC. Not all the Ct values during the patients' stay at the Haihe Hospital were stored in the electronic health records, but the binary classifications of 'positives' (Ct ≤40) and 'negatives' (Ct >40) were always recorded. The epidemiological data for Shanghai were available at the webpage of the Shanghai Municipal Health Commission (https://wsjkw.sh.gov.cn/xwfb/index.html).

Statistical analysis

Time to viral clearance was used as the main outcome measure, because it was mandated by the National Health Commission of China to be the primary eligibility criterion for hospital discharge.[16]

Due to the high dimensionality of our data (52 variables that included age, complete blood counts, blood biochemistry, electrolytes and anti-SARS-CoV-2 antibodies (table 1)) relative to the size of the patient cohort, we first normalised each clinical feature to have mean 0 and SD 1 across all the patients and then reduced dimensionality through the Uniform Manifold Approximation and Projection algorithm using the 'umap' package in R. Each patient was now represented as one dot in a two-dimensional space. We then overlaid a 200-by-200 grid across the two-dimensional space. Each grid point induced a binary classification of the patients: those who were in the neighbourhood of the grid point (within D distance), and those who were not. We then performed Cox regression on this binary classification against viral clearance. A grid point whose p value was $<\theta$ and whose Cox regression coefficient was positive was marked as an 'anchor point'. We repeated this procedure for all the grid points until we identified all the anchor points. A patient that fell within αD distance of an anchor point was deemed 'predicted earlier viral clearance'.

To guard against overfitting, the patients were divided into two halves that were approximately equal in size: the patients before (excluding) 15 January constituted the training set, and the rest of the patients constituted the validation set. The set of anchor points were calculated solely based on the training set. Sensitivity analysis was conducted by varying the parametric values of D, θ and α.

Table 1 Basic information of the 417 PCR-positive patients during the first omicron wave in Tianjin, China

Variables	Data available no. (%)	Min	Q1	Median	Q3	Max	p value	Reference range	Below no. (%)	Normal no. (%)	Above no. (%)
Age, years	417 (100.0)	0.3	19	37	56	90					
Sex	417 (100.0)										
Male	189 (45.3)										
Female	228 (54.7)										
Race	417 (100.0)										
Han	411 (98.6)										
Manchu	4 (1.0)										
Hui	1 (0.2)										
Mongol	1 (0.2)										
Symptoms at admission*	417 (100.0)										
No or mild symptoms	267 (64.0)										
Moderate	149 (35.7)										
Severe	1 (0.2)†										
CURB-65 score[35]	417 (100.0)										
0	317 (76.0)										
1	85 (20.4)										
2	15 (3.6)										
COVID-19 vaccination status	415 (99.5)										
0 dose	38 (9.1)										
1 dose	20 (4.8)										
2 doses	192 (46.0)										
3 doses	165 (39.6)										
Anti-SARS-CoV-2 IgG S/CO	397 (95.2)	0.03	2.63	20.19	48.89	265.86		[0.00, 1.00)	NA	61 (15.4)	336 (84.6)
Vaccinated with 0 dose	34 (8.2)	0.03	0.08	0.14	0.22	191.36		[0.00, 1.00)	NA	32 (94.1)	2 (5.9)
Vaccinated with 1 dose	19 (4.6)	0.06	1.72	3.09	14.72	264.09	<0.001‡	[0.00, 1.00)	NA	4 (21.1)	15 (78.9)
Vaccinated with 2 doses	180 (43.2)	0.05	2.19	13.10	37.20	255.71	<0.001‡	[0.00, 1.00)	NA	23 (12.8)	157 (87.2)
Vaccinated with 3 doses	162 (38.8)	0.30	16.84	34.03	66.78	265.86	<0.001‡	[0.00, 1.00)	NA	2 (1.2)	160 (98.8)
Anti-SARS-CoV-2 IgM S/CO	397 (95.2)	0.02	0.09	0.19	0.44	13.80		[0.00, 1.00)	NA	356 (89.7)	41 (10.3)
Vaccinated with 0 dose	34 (8.2)	0.03	0.06	0.08	0.14	0.52		[0.00, 1.00)	NA	34 (100.0)	0 (0.0)
Vaccinated with 1 dose	19 (4.6)	0.03	0.07	0.11	0.31	13.80	0.14‡	[0.00, 1.00)	NA	17 (89.5)	2 (10.5)
Vaccinated with 2 doses	180 (43.2)	0.02	0.09	0.23	0.52	6.52	<0.001‡	[0.00, 1.00)	NA	160 (88.9)	20 (11.1)
Vaccinated with 3 doses	162 (38.8)	0.02	0.11	0.21	0.45	8.90	<0.001‡	[0.00, 1.00)	NA	143 (88.3)	19 (11.7)

Continued

Table 1 Continued

Variables	Data available no. (%)	Min	Q1	Median	Q3	Max	p value	Reference range	Below no. (%)	Normal no. (%)	Above no. (%)
Day of viral clearance	417 (100.0)	3	8	10	12	28					
Body temperature, ℃	417 (100.0)	35.6	36.4	36.7	37.2	39.1		<38.0	NA	389 (93.3)	28 (6.7)
Pulse rate, /min	417 (100.0)	51	78	88	98	140		[60, 100)	5 (1.2)	323 (77.5)	89 (21.3)
Breathing rate, /min	417 (100.0)	12	18	20	20	40		[16, 20)	6 (1.4)	195 (46.8)	216 (51.8)
Systolic pressure, mm Hg	417 (100.0)	80	112	126	138	199		[90, 140)	2 (0.5)	315 (75.5)	100 (24.0)
Diastolic pressure, mm Hg	417 (100.0)	50	70	80	89	135		[60, 90)	16 (3.8)	299 (71.7)	102 (24.5)
Oxygen saturation, %	416 (99.8)	90	97	98	98	100		≥95	20 (4.8)	396 (95.2)	NA
Carbon dioxide, mmol/L	402 (96.4)	15	26	27	29	34		[22, 30)	8 (2.0)	314 (78.1)	80 (19.9)
Haemoglobin, g/L	416 (99.8)	63	128	138	148	184		[115, 150)	32 (7.7)	295 (70.9)	89 (21.4)
Red cell count, 10^{12}/L	416 (99.8)	2.60	4.33	4.68	5.02	6.50		[3.80, 5.10)	19 (4.6)	314 (75.5)	83 (19.9)
White cell count, 10^9/L	416 (99.8)	1.88	4.46	5.42	7.02	20.97		[3.50, 9.50)	33 (7.9)	357 (85.8)	26 (6.3)
Neutrophil count, 10^9/L	416 (99.8)	0.78	2.20	3.13	4.36	18.61		[1.80, 6.30)	54 (13.0)	330 (79.3)	32 (7.7)
Lymphocyte count, 10^9/L	416 (99.8)	0.29	1.03	1.45	1.95	7.85		[1.10, 3.20)	117 (28.1)	282 (67.8)	17 (4.1)
Monocyte count, 10^9/L	416 (99.8)	0.13	0.47	0.64	0.80	1.69		[0.10, 0.60)	0 (0.0)	183 (44.0)	233 (56.0)
Platelet count, 10^9/L	416 (99.8)	37.0	188.8	227.5	271.2	579.0		[125.0, 350.0)	14 (3.4)	380 (91.4)	22 (5.2)
Albumin, g/L	403 (96.6)	28.4	40.6	43.2	46.0	53.2		[40.0, 55.0)	77 (19.1)	326 (80.9)	0 (0.0)
Aspartate aminotransferase, U/L	403 (96.6)	15	22	25	32	201		[14, 36)	0 (0.0)	340 (84.4)	63 (15.6)
Alanine aminotransferase, U/L	403 (96.6)	5	14	19	29	463		<35 (female) <50 (male)	NA	355 (88.1)	48 (11.9)
AST/ALT ratio	403 (96.6)	0.39	0.96	1.32	1.75	3.85		[0.80, 1.50)	57 (14.1)	187 (46.4)	159 (39.5)
Total bilirubin, μmol/L	403 (96.6)	1.80	4.40	7.40	11.25	53.40		[3.00, 22.00)	37 (9.2)	354 (87.8)	12 (3.0)
Indirect bilirubin, μmol/L	403 (96.6)	1.30	3.90	6.90	10.75	52.90		[0.00, 19.00)	NA	384 (95.3)	19 (4.7)
Alkaline phosphatase, U/L	403 (96.6)	20	54	70	99	408		[38, 126)	18 (4.5)	299 (74.2)	86 (21.3)
Creatinine, μmol/L	403 (96.6)	15	43	53	67	115		[46, 92)	126 (31.2)	265 (65.8)	12 (3.0)
Urea, mmol/L	403 (96.6)	1.81	3.39	4.18	5.06	8.62		[2.50, 6.10)	17 (4.2)	350 (86.9)	36 (8.9)
Uric acid, μmol/L	403 (96.6)	103	249	301	367	596		[149, 369)	4 (1.0)	301 (74.7)	98 (24.3)
C reactive protein, mg/L	413 (99.0)	0.18	0.92	2.95	7.64	287.26		[0.00, 10.00)	NA	342 (82.8)	71 (17.2)

*No or mild symptoms: chest CT showing no signs of pneumonia. Severe: breathing rate ≥30/min, oxygen saturation ≤93%, PaO_2/FiO_2 (ratio of arterial oxygen pressure (expressed in mmHg) to fractional inspired oxygen (expressed as a fraction)) ≤300 mm Hg or chest CT evidence of disease expanding >50% within 48 hours. Moderate: in between 'no or mild symptoms' and 'severe'.[16]
†Coma induced by high intracranial pressure due to metastasis of lung cancer to the brain.
‡Compared with unvaccinated patients (two-sided Wilcoxon test).
ALT, alanine aminotransferase; AST, aspartate aminotransferase; NA, not applicable; Q1, 25th percentile; Q3, 75th percentile; S/CO, signal-to-cutoff ratio.

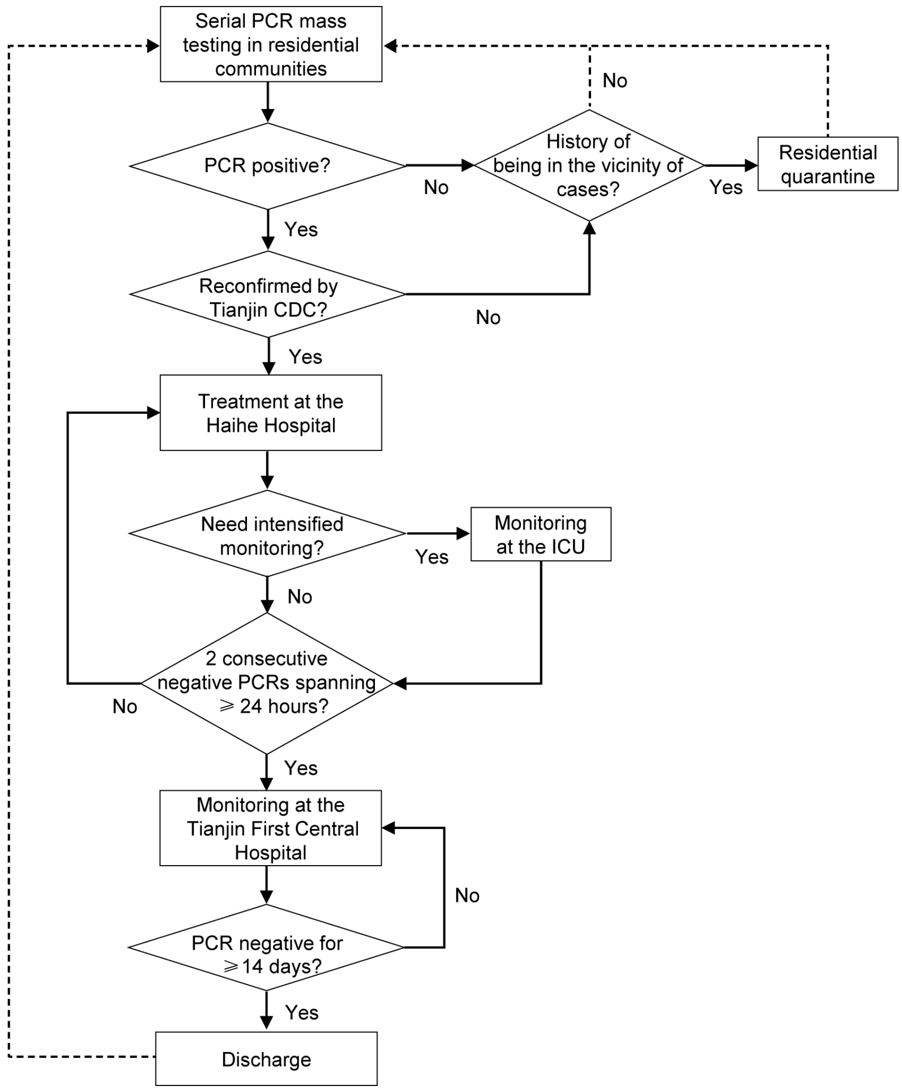

Figure 1 The city-wide flowchart for implementing the 'dynamic zero-COVID' policy in Tianjin, China. CDC, Centers for Disease Control and Prevention; ICU, intensive care unit.

To further validate the statistical significance of the feature cluster associated with earlier viral clearance and to correct for the effects of potential confounding factors, Cox regression was conducted with age, sex, COVID-19 vaccination status, anti-SARS-CoV-2 antibodies, symptom severity at diagnosis and treatments included as the covariates.

All comparisons between distributions were conducted using the two-sided Wilcoxon test. All computation was performed in the R programming language (R-4.1.1).

RESULTS

The city-wide flow chart for implementing the 'dynamic zero-COVID' policy is available in figure 1.

Starting from 9 January 2022, Tianjin initiated multiple rounds of city-wide PCR mass testing with 24-hour turnaround in each round. This strict measure was implemented when the rate of daily new cases was still <0.4 per 1 000 000 residents per day. In contrast, when later Shanghai was battling its own omicron wave, mass testing was not intensified until the rate of daily new cases already surpassed 8 per 1 000 000 residents (figure 2A).

Daily new cases in Tianjin peaked at 59 on 16 January and dropped to <5 after 3 February, 26 days after the first cases (figure 2B). The number of affected residential subdivisions peaked at 38 on 18 January and dropped to ≤2 after 13 February, 36 days after the first cases. There was no death. Although the authors could not acquire from the Tianjin CDC the exact daily numbers of residents living in affected residential subdivisions, we estimated that the peak number of quarantined residents was less than 3% of the 14 million residents in Tianjin, since a typical residential subdivision has less than 10 000 residents.

For 297 (71.2%) of the 417 cases, we could ascertain their Ct values in the community PCR screenings (that is, before admission to the Haihe Hospital) from the Tianjin CDC, and their median value was 24.9 (range 8.8–39.3; 25th percentile (Q1), 20.7; 75th percentile (Q3), 27.6).

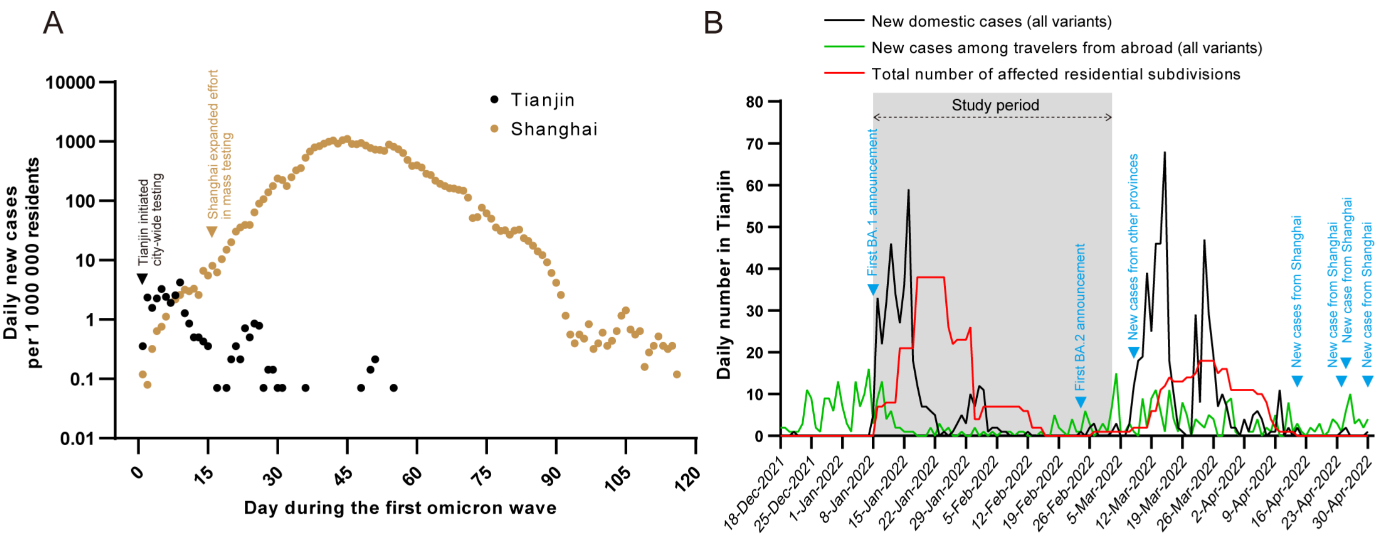

Figure 2 Implementation of the 'dynamic zero-COVID' policy in Tianjin, China. (A) Comparison between Tianjin's and Shanghai's first omicron waves. 'Day 0' was defined as the first day when the number of daily new cases surpassed 0.1 per 1 000 000 residents. In Tianjin, day 0 was 8 January 2022; in Shanghai, day 0 was 28 February 2022. (B) Daily new cases and affected residential subdivisions in Tianjin from December 2021 to April 2022.

The median interval from Haihe admission to Haihe discharge was 13 days (figure 3A). On average, a patient underwent serial PCR tests on 7 days (average 17.5 PCR tests) during his or her stay at the Haihe Hospital. The median interval from Haihe admission to viral clearance was 10 days (range 3–28; Q1, 8; Q3, 12). At admission, 64.0% (267/417) of the patients had no or mild symptoms (figure 3B and table 1). One (0.2%) patient with a history of anxiety disorder received anxiolytic medication.

4.1% (17/417) of the patients (median age, 72 (range 25–89)) were admitted to the intensive care unit (ICU), with the median stay of 9 days (range 4–13 days). None of the patients admitted to the ICU required mechanical ventilation. The most common reason for the ICU admissions was progression of pulmonary diseases (41.2% (7/17)), followed by dyskinesia (17.6% (3/17)) and heart diseases (17.6% (3/17)). Under other circumstances, none of the patients admitted to the ICU at the Haihe Hospital would normally be admitted to the ICU, and the 17 patients were transferred to the ICU primarily for intensified monitoring. It should be noted that the ICU at the Haihe Hospital was dedicated to COVID-19; therefore, no other patient in Tianjin was prevented from ICU admission due to the intensified monitoring of these 17 COVID-19 patients.

To investigate if it was possible to shorten the isolation period of PCR-positive patients, we sought to identify a clinical signature that was associated with earlier viral clearance (figure 4A). Using a two-dimensional visual representation of 52 phenotypic features, we identified a phenotypic cluster that was associated with earlier viral clearance (figure 4B). The phenotypic cluster comprised younger age, higher lymphocyte percentage, lower creatinine, higher alkaline phosphatase, lower γ-glutamyltransferase and lower blood pressures (figure 4C). Sensitivity analysis confirmed that our finding was not specific to particular parametric values of *D*, *θ* and *α* (online supplemental file 1). Sex, vaccination status and symptoms at admission did not provide additional value to predicting viral clearance (online supplemental file 1).

After discharge from the Haihe Hospital, 23.7% (99/417) of the patients experienced PCR repositivity (Ct range 20–40; Q1, 30; median, 33; Q3, 35) during convalescence at TFCH. While we did not assess viral viability of the collected samples, none of the repositivity cases experienced symptom exacerbation, and 95% (94/99) returned to PCR negativity within 11 days (Q1, 1 day; median, 3 days; Q3, 6 days). One repositivity case did not return to PCR negativity until 37 days later; that patient had been in the vegetative state since a car accident 5 years ago.

Additional data of the same set of patients during convalescence at TFCH are available in a recently published paper by Zheng *et al*[17]; in that article (coauthored by YX and WJ), all the reported laboratory test results were collected in the recovery phase, that is, after discharge from the Haihe Hospital.

DISCUSSION

Here we report the trends for daily new cases and affected residential subdivisions in Tianjin during the first omicron wave on the Chinese mainland.

Study strengths include that ours was a city-wide study with uniform screening and treatment protocols for the general population and all the PCR-positive cases, we were able to access PCR reconfirmation results at the Haihe Hospital to remove the false positives in the public records, high-frequency serial PCR testing both in the residential communities and at the Haihe Hospital allowed more accurate determination of time to viral clearance,[18] and a multidimensional approach to phenotypic analysis

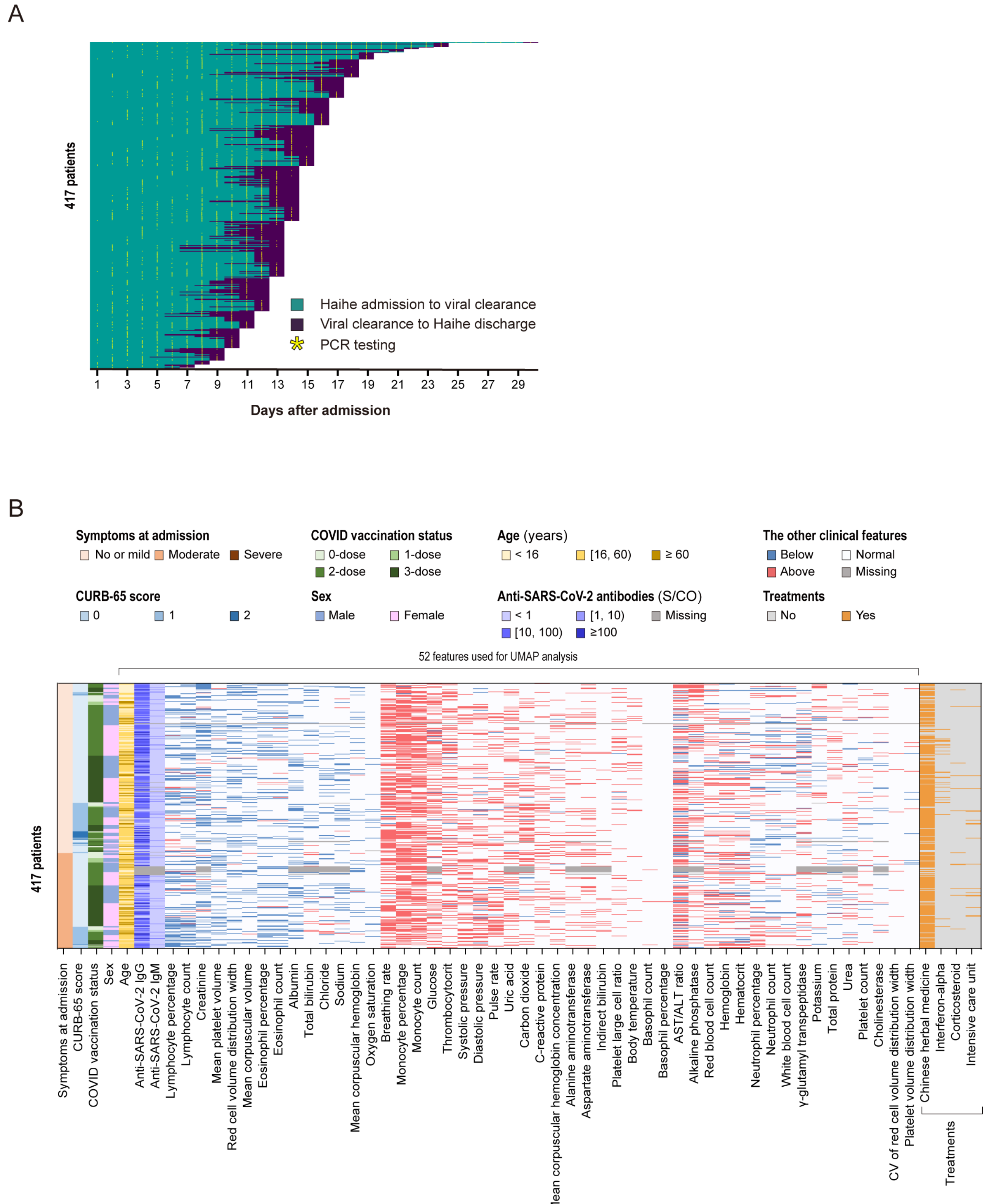

Figure 3 Viral clearance and clinical manifestations of the first omicron wave in Tianjin, China. (A) Distribution of the timelines for Haihe admission, serial PCR testing, viral clearance and Haihe discharge. The patients are ordered by the length of their stay at the Haihe Hospital. (B) Clinical features at diagnosis and received treatments. The normal range for each variable is available in table 1. S/CO, signal-to-cutoff ratio.

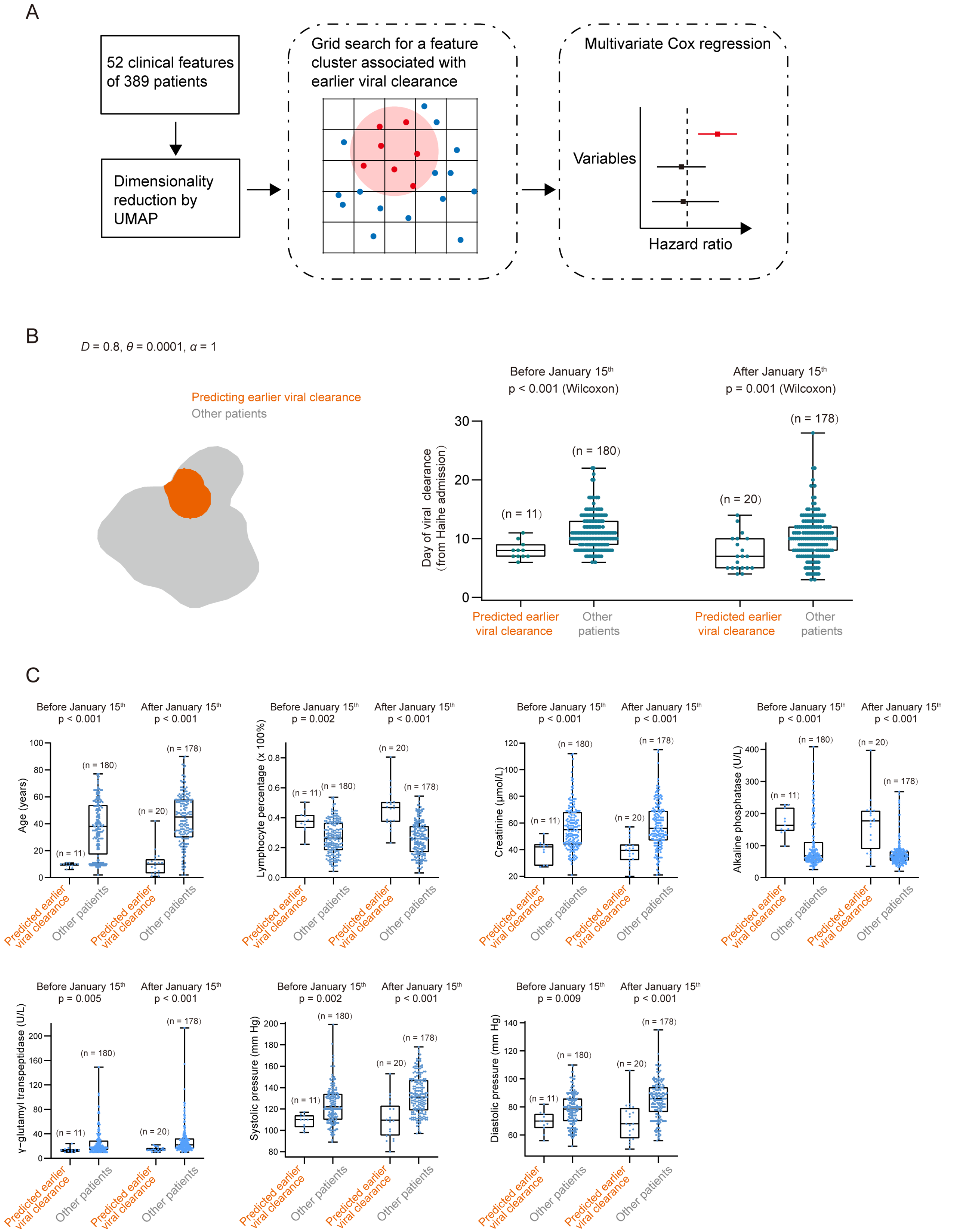

Figure 4 A phenotypic cluster at diagnosis that was associated with earlier viral clearance. (A) Analytical flow chart. (B) UMAP embedding of the patients onto a two-dimensional space using 52 features at diagnosis. A phenotypic cluster predicting earlier viral clearance was calculated based on the patients diagnosed before (excluding) 15 January and validated on the rest of the patients. (C) Clinical features at diagnosis that were associated with earlier viral clearance. The p values were calculated using the two-sided Wilcoxon test. UMAP, Uniform Manifold Approximation and Projection.

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enabled the identification of a feature cluster associated with earlier viral clearance.

Study limitations include that this was a retrospective study, a randomised clinical trial for comparing different public-health strategies was not feasible, the time course of infectiousness was not assessed,[18] comparison with non-omicron COVID-19 cases was not conducted, and detailed clinical data were not available for head-to-head comparison of Tianjin vs Shanghai during their respective omicron waves.

The key components of Tianjin's implementation of the 'dynamic zero-COVID' policy were threefold: First, the affected residential subdivisions were immediately quarantined. Unlike in 2020, when whole-city 'lockdown' was widely practised,[19–21] at any given time >97% of the residents in Tianjin could buy groceries and go to work during the studied omicron wave. Second, city-wide serial, fast-turnaround PCR mass testing was immediately rolled out. Both the PCR testing frequency and turnaround time play crucial roles in effective COVID-19 screening,[22] and Tianjin has put much emphasis on both frequency and speed. Third, residential quarantine and serial PCR mass testing were dynamically adjusted according to the case trends. Our data suggest that, if implemented very early (eg, when the number of daily new cases is <0.4 per 1 000 000 residents), 'dynamic zero-COVID' could suppress an omicron wave within a month of its initiation, potentially avoiding excess deaths in the general population. After the first omicron wave, Tianjin experienced another wave of cases originating in migrant workers from other provinces starting from 8 March,[23] and again the second wave was suppressed within a month using the same public health strategy described in this article.

Note that the Tianjin approach to 'dynamic zero-COVID' invested a high density of resource on each PCR-positive case. This was possible, because the total number of positive cases city-wide was controlled below a critical value dictated by the healthcare capacity. Under other circumstances such as when the healthcare resource is severely limited or the general public is more receptive of 'living with COVID-19', the Tianjin approach described in this article might not be applicable.

One recent theoretical study examined the possibility of dynamically adjusting business closures to minimise the impact of 'lockdowns' on the gross domestic product[24]; while we agree with this concept in principle, we caution that in many Chinese cities there is considerable spatial overlap of different economic activities, and city zoning should be an additional important factor to consider in public-health models.

We affirmed low rates of severe diseases and deaths among the omicron cases. The ICU admission rate (4.1%) in our study was much higher than what was reported previously in omicron cases in southern California (0.02%)[6] and Marseille, France (0.09%).[7] Most of our ICU admissions, however, were to ensure better monitoring of the patients' comorbidities. Our study did agree with these earlier studies regarding the low rates of mechanical ventilation and mortality (both ≤0.1%). It should be noted that the low mortality rate of omicron cases does not necessarily translate to few deaths in the general population; indeed, a recent study in Massachusetts found that omicron directly or indirectly caused 2294 excess deaths (equivalent to 0.3 excess deaths per 1000 residents) over an 8-week period in a population of 6.9 million residents.[10]

We found that viral clearance often happened 8–12 days after the initial PCR positivity. In addition, we identified a phenotypic cluster that predicted earlier viral clearance. Therefore, in the future, it might be possible to adjust the isolation period according to each case's clinical features. Like previous reports,[25 26] we affirmed that younger age and higher lymphocyte count were associated with earlier viral clearance. The multidimensional approach in this study echoes recent advances in phenotypic analysis in other diseases.[27–29]

It has been well documented that prolonged isolation—either in residential compounds or at a medical facility—may lead to mental distress.[1 30] During the study period, several measures were undertaken to minimise mental distress and financial burden for the PCR-positive cases: First, family members were treated in the same room whenever possible. Second, the entire stay at the Haihe Hospital was free of charge. We did not quantify the level of mental distress experienced by the PCR-positive cases during hospitalisation. Except for one patient who received anxiolytic medication, however, none of the other cases required psychiatric intervention during their stay at the Haihe Hospital. It should be noted that the level of experienced mental distress attributed to 'dynamic zero-COVID' is possibly correlated with a person's prior attitude towards 'dynamic zero-COVID';[30] therefore, our experience in Tianjin might not extrapolate to other populations.

While it is not the intent of this article to provide an ethical analysis of 'dynamic zero-COVID', the authors would like to point out that the strictness of a public regulation need not correlate with the chance of severe outcomes.[31] As a point of reference, consider this example: In 2019, driving under the influence of alcohol (DUI) led to 1 024 508 arrests and 10 142 deaths in the USA.[32 33] Taking into account that not all DUI led to arrests, one can deduce that on average <1% of DUI instances result in fatality. Nonetheless, most countries—China included—have strict criminal laws against DUI. With high population densities in many of the urban regions in China, the risk of widespread COVID-19 epidemic and its associated excess deaths is not a risk that can be easily discounted. Even in the well-resourced USA and even in October 2022, the country's CDC forecasted that >2000 people would die of COVID-19 every week.[34] The authors submit that it is logical for a developing country such as China to take a cautious pace when deciding its public health policy.

Author affiliations

[1]State Key Laboratory of Experimental Hematology, National Clinical Research Center for Blood Diseases, Haihe Laboratory of Cell Ecosystem, Institute of Hematology & Blood Diseases Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, Tianjin, China
[2]Department of Infectious Disease, Haihe Clinical School, Tianjin Medical University, Tianjin, China
[3]Organ Transplant Center, NHC Key Laboratory for Critical Care Medicine, Tianjin First Central Hospital, Tianjin, China
[4]School of Clinical Medicine, Medical College, Tianjin University, Tianjin, China

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Patient consent for publication Not applicable.

Ethics approval This retrospective study was initiated by the Tianjin Municipal Health Commission (order no. JWKJ-282). The ethics committee of the Haihe Laboratory of Cell Ecosystem reviewed the study design's adherence to privacy protection and other ethics requirements and approved this study (HHL202205-EC-1). All costs incurred during PCR mass testing and hospitalisation were free of charge to the patients. Each patient signed an informed consent to participate in this study at the time of transfer from the Haihe Hospital to the TFCH. All the participants gave informed consent to participate in the study before taking part.

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ORCID iD

Junren Chen http://orcid.org/0000-0003-3691-4931

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