Preplanned Studies

Assessment of the Potential for Cross-Border Transmission of Infectious Diseases via Commercial Air Travel — Shanghai Municipality, China, 2019–2023

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Summary

What is already known about this topic?

Despite the end of coronavirus disease 2019 (COVID-19) as a public health emergency of international concern (PHEIC), the changes in risks of travel-related infectious diseases and their impact on global health quarantine still call for great concern.

What is added by this report?

Our study indicated that the pattern of changes in the positive detection rate of arrivals was basically in line with the disease incidence in countries from which travel was initiated.

What are the implications for public health practice?

Accurate risk assessment at entry-exit ports can significantly enhance the efficiency of targeting high-risk international arrivals, especially in the early stages of epidemic control and prevention when available data are insufficient.

On May 5, 2023, the World Health Organization (WHO) announced that coronavirus disease 2019 (COVID-19) no longer constituted a public health emergency of international concern (PHEIC) (*1*). However, cross-border travel remains a key driver of the global spread of infections (*2*), and the changes in risks of imported travel-related infectious diseases and their impact on global health quarantine still warrant significant concern (*3*–*4*). Therefore, it is crucial to enhance the capacity of frontier public health administration to effectively detect and respond to potential inbound infected individuals. We conducted a study of frontier public health administration, assessing the potential for cross-border transmission of infectious diseases before and after the pandemic via commercial air travel and the efficiency of quarantine measures implemented at Shanghai international airports. Our study indicated that the pattern of changes in the positive detection rate by Shanghai Customs District among inbound travelers was generally in line with the disease incidence in countries from which travel originated. Our analyses showed that accurate risk assessment at points of entry would offer significant efficiency for screening out arriving individuals who had travel histories from affected countries, histories of infection, or infectious contact, especially in the early stages of epidemic control and prevention when available data are inadequate.

We analyzed epidemiological surveillance data for all travel-related infectious diseases at entry points in Shanghai and compared the distributions and contributing factors of these diseases in 2019 (pre-pandemic) and 2023 (post-pandemic). We calculated descriptive statistics for all variables and summarized continuous variables as median and range. We estimated the incidence of various infectious diseases among inbound travelers at Shanghai's 2 international airports. We calculated proportions according to various categories and constructed graphs to show the distribution patterns of proportions among different departure or exposure countries.

China Customs implemented entry quarantine measures at ports of entry as appropriate in response to suspected imported infectious diseases. These measures included health declaration verification, fever screening, epidemiological investigation, and nucleic acid testing. In 2023, 10.1 million international travelers arrived in Shanghai and underwent entry quarantine inspections, representing a 57.5% decrease from the pre-pandemic (2019) level. A total of 5,252 suspected infections were identified: 5,198 (98.97%) respiratory, 45 (0.86%) gastrointestinal, and 9 (0.17%) vector-borne. This amounted to an overall incidence of 5.2 per 10,000 travelers, a 2.5-fold increase from the pre-pandemic level. The proportion of respiratory infections increased by 10 percentage points, while gastrointestinal and vector-borne infections decreased

by 8 and 3 percentage points, respectively (Table 1).

In early 2019, Shanghai Customs District began employing the Customs Surveillance and Warning System (hereinafter referred to as "the System") at its entry points, which became the major approach to detecting suspected cases instead of fever screening. In 2023, the system detected a total of 3,217 imported cases (61.25%) at entry screening, of which 1,116 (21.25%) were detected by medical inspection, 675 (12.85%) by health declaration, 202 (3.85%) by fever screening, and 41 (0.78%) by declaration of conveyance operators. However, in 2019 (pre-pandemic), 1,367 imported cases (90.95%) were detected by fever screening at entry screening, and 85 (5.66%) by declaration of conveyance operators. These results show that accurate risk assessment at entry-exit ports provides significant efficiency for screening out arriving individuals with travel histories of affected countries and histories of infection or infectious contact. According to our data, the incidence of high-risk arriving individuals targeted by accurate risk assessment at entry screening was 65 times that of low-risk individuals. For mega entry-exit ports, accurate risk assessment is beneficial for maximizing epidemic prevention effects with minimal input.

The occupational composition of imported cases differed significantly between 2019 (pre-pandemic) and 2023 (post-pandemic). In 2023, the three largest traveler groups were laborers [1,596 (30.39%)], businesspeople [1,013 (19.29%)], and students [607 (11.55%)], collectively representing 61.23% of imported cases). Compared to the pre-pandemic period, 2023 saw a sharp decline in the proportion of tourists, constituting only 5.0%. The sociodemographic characteristics of travelers from different countries also contributed to the risk of imported infections.

The number of imported cases varied significantly by point of departure. In 2023, most were from nonstop Shanghai-bound flights originating from 88 countries and regions, including 10 American, 27 European, 9 Middle Eastern, 17 African, 4 Oceanian, and 21 Asian countries. Most inbound travelers arrived from Southeast Asia and South Asia [1,719 (33.3%)], East Asia [1,235 (23.9%)] while most identified cases were imported from Thailand, Japan, and South Korea. The geographic distribution of imported cases at points of departure closely resembled that of the pre-pandemic period. In 2019, most imported cases originated near Chinese mainland, including South Asia and Southeast Asia [444 (33.53%)], and East Asia [402 (30.36%)]. The incidence of imported infections was a key contributing factor to entry screening positive detection rates. This influence was more significant for vector-borne infectious diseases, which are closely related to seasonal factors.

The positive detection rate of imported diseases at entry points was significantly influenced by disease incidence in travelers' countries/regions of origin. In 2023, peaks in the weekly positive detection rate of entry screening in Shanghai mirrored incidence trends in several countries and regions (Figure 1). This correlation was particularly strong for travelers from Thailand, Singapore, Vietnam, Iran, Russia, and Italy, although changes in the positive detection rate lagged slightly behind incidence rate changes, reflecting the time lag between outbreak and cross-border transmission. However, due to variations in surveillance techniques, healthcare capacity, information transparency, and data accessibility among countries, the incidence rate in some countries, such as the UAE, declined sharply. Nonetheless, in the early stages, changes in the positive detection rate generally aligned with disease incidence in travelers' countries of origin.

DISCUSSION

To our knowledge, this is the first cross-sectional study comparing cross-border-related infections among travelers arriving to the Chinese mainland before and after the COVID-19 pandemic. Our findings, based on inspection and quarantine data for 10.1 million travelers who arrived in Shanghai from 88 countries and regions worldwide, can help to better understand the significance of scientific and precise entry inspection and quarantine measures. These measures are essential to control and prevent the potential risk of imported infections and continuously enhance the capacity of controlling disease importation in Shanghai.

Compared to pre-pandemic measures against severe airborne and contact-transmitted infectious diseases such as SARS, highly pathogenic avian influenza, and Ebola, Chinese mainland implemented more complicated and stricter measures to control the importation of COVID-19. This optimized System model effectively targeted and detected most imported infections in 2023 under the Shanghai-based frontier quarantine system. For example, since tourist numbers have not returned to pre-pandemic levels, overseas Chinese laborers — who were primarily employed in

TABLE 1. Characteristics of the cases detected through entry quarantine before & after the epidemic.

Variable	Post-epidemic (*n*=5,252)	Pre-epidemic (*n*=1,503)	*P*[*]
Sex[†]			0.014
Male	2,949 (56.2)	898 (59.7)	
Female	2,300 (43.8)	605 (40.3)	
Age, years[†]			<0.001
≤9	193 (3.7)	196 (13.0)	
10–19	299 (5.7)	245 (16.3)	
20–39	2,610 (50.0)	551 (36.7)	
40–59	1,590 (30.5)	334 (22.2)	
≥60	529 (10.1)	177 (11.8)	
Nationality[†]			<0.001
Chinese	4,030 (76.8)[§]	1,153 (76.7)[¶]	
Foreign	1,220 (23.2)	350 (23.3)	
Occupation			<0.001
Laborer	1,596 (30.4)	3 (0.2)	
Student	607 (11.5)	27 (1.8)	
Crew	20 (0.4)	2 (0.1)	
Sailor	128 (2.4)	1 (0.1)	
Diplomatic Personnel and Entourage	28 (0.5)	0 (0.0)	
Business	1,013 (19.3)	127 (8.4)	
Child	98 (1.9)	28 (1.9)	
Retiree	184 (3.5)	15 (1.0)	
Others	1,578 (30.0)	1,300 (86.5)	
Country of departure[†, **]			<0.001
China[††]	845 (16.4)	212 (16.0)	
East Asian countries	1,235 (23.9)	402 (30.4)	
South-East Asian & South Asian countries	1,719 (33.3)	444 (33.5)	
Middle Eastern countries	334 (6.5)	42 (3.2)	
European countries	736 (14.2)	97 (7.3)	
African countries	47 (0.9)	24 (1.8)	
North American countries	157 (3.0)	67 (5.1)	
South American countries	21 (0.4)	4 (0.3)	
Oceanian countries	71 (1.4)	32 (2.4)	
Symptom Upon Entry			<0.001
Asymptomatic	3,434 (65.4)	0 (0.0)	
Fever	864 (16.4)	1,367 (91.0)	
Other symptoms	954 (18.2)	136 (9.0)	
Clinic Diagnosis			<0.001
Respiratory	5,198 (99.0)	1,331 (88.6)	
Gastrointestinal	45 (0.8)	128 (8.5)	
Insect-borne	9 (0.2)	44 (2.9)	

Note: Data are reported as *n* (%).
Abbreviation: SAR=Special Administrative division.
[*] *P* calculated using χ^2 test.
[†] Data have missing values for post-epidemic.
[§] Data included 3,657 (69.7%) of Chinese (mainland) and 373 (7.1%) of Chinese (Hong Kong SAR, Macao SAR, and Taiwan, China).
[¶] Data included 1,084 (72.1%) of Chinese (mainland) and 69 (4.6%) of Chinese (Hong Kong SAR, Macao SAR, and Taiwan, China).
[**] Data have missing values for pre-epidemic.
[††] Data included Hong Kong SAR, Macao SAR, and Taiwan, China.

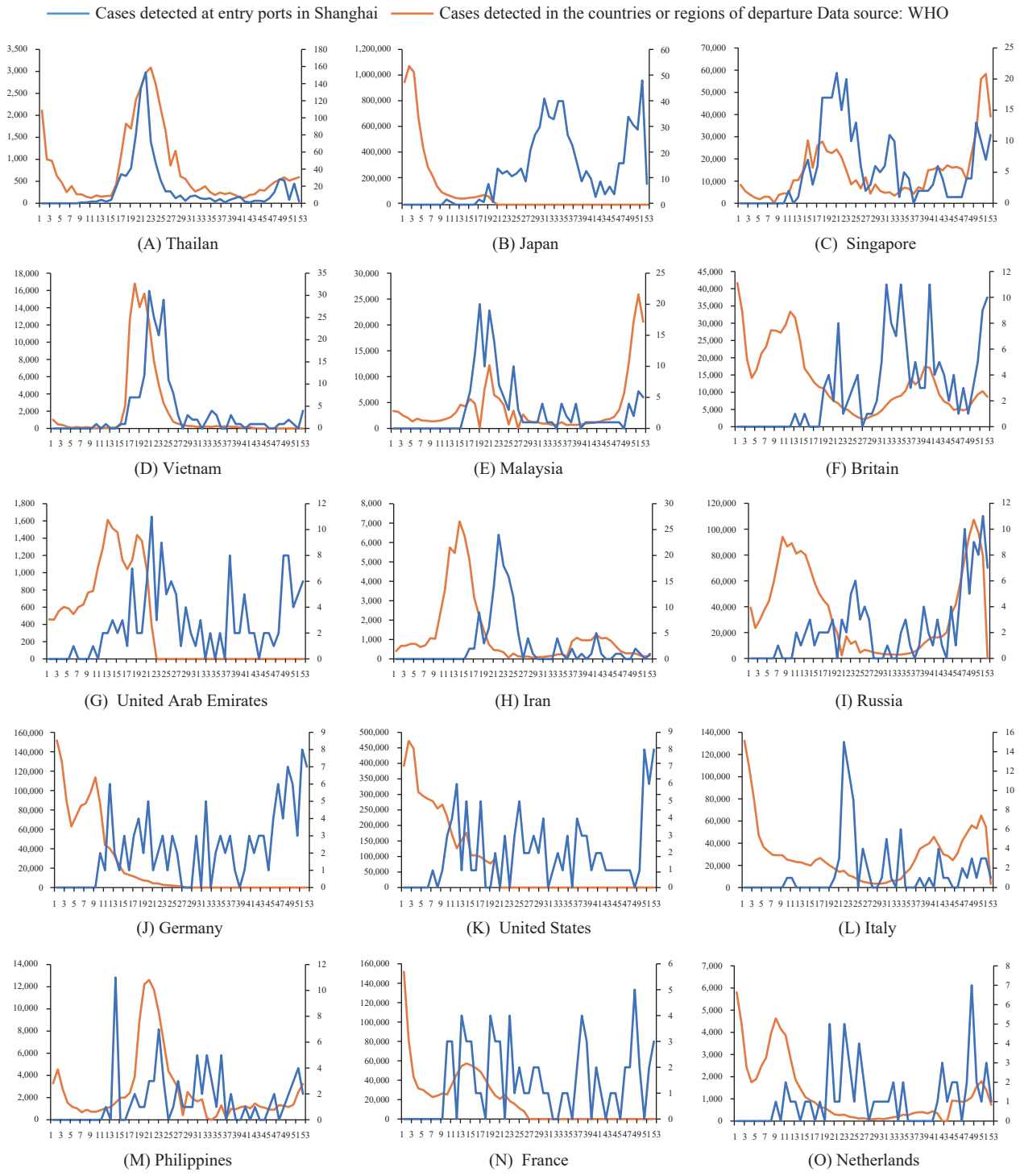

FIGURE 1. Cross-border infection peaks by the weekly positive detection rate in Shanghai in Year 2023. (A) Thailand; (B) Japan; (C) Singapore; (D) Vietnam; (E) Malaysia; (F) Britain; (G) United Arab Emirates; (H) Iran; (I) Russia; (J) Germany; (K) United States; (L) Italy; (M) Philippines; (N) France; and (O) Netherlands.

the manufacturing, construction, forestry, fishing, transportation, and catering industries — and students constituted the two main groups with imported infections in 2023. Both groups experienced high population density and prolonged exposure abroad, representing a substantial proportion of travelers with a comparatively high infection density. Moreover, the entry dates of these two groups were concentrated within a small range, enabling the use of big data analytics to identify their mobility characteristics and

formulate targeted risk assessments and specific frontier quarantine plans. Nevertheless, optimizing the System remains challenging. Medical screening at points of entry lacks effective and accurate methods to identify asymptomatic or incubatory carriers of airborne and contact-transmitted infectious diseases in commercial air travel settings. Additionally, the amount of valid data collected through quarantine at entry ports has decreased sharply following the post-pandemic adjustments to quarantine measures.

This study is limited by the absence of valid data analyzing the risk of infection during international flights, an important factor warranting further attention. Passengers and crew members on long-duration, non-stop international flights occupy a crowded, confined environment for extended periods. Without consistent, adequate protective measures, individuals may readily acquire infection through airborne transmission and close contact via droplets and surfaces, respectively. Crew member infection further elevates the risk of transmission. Analysis of inbound flights with multiple infected individuals revealed distribution patterns, including the concentration of infected individuals within a specific cabin area or along the aisles serviced by an infected crew member. However, identifying potentially infected individuals at entry health screenings remains challenging due to the early stage of infection. Effective control measures for mitigating infection risk during international flights require further investigation.

For centuries, countries have quarantined travelers arriving at their borders to protect their health, security, and economic interests (*5*–*6*). Our findings provide a comprehensive risk profile for various imported infections at international airports in Shanghai. These findings also demonstrate the effectiveness of screening and quarantine measures, which do not impact regular customs clearance procedures for international travelers or the international trade order based in Shanghai. Scientifically sound and efficient quarantine measures at points of entry can help with the timely identification of individuals with emerging or re-emerging infections, preventing local transmission (*7*). These measures contribute to proactive action plans to combat the next Disease X (*8*) and prepare for worst-case scenarios. However, with the rapid development of ports and increasing numbers of cross-border travelers, port-based health inspection and quarantine procedures should be further strengthened. This can be achieved through more effective on-site medical screening approaches, rapid laboratory testing technologies, and more complex algorithms based on big data. These improvements will help realize the purpose and scope of the International Health Regulations (IHR), which aim to prevent, protect against, control, and provide a public health response to the international spread of disease. This should be conducted in ways commensurate with and restricted to public health risks, while avoiding unnecessary interference with international traffic and trade (*9*).

Conflicts of interest: No conflicts of interest.

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