The analysis of the characteristics of imported COVID-19 cases from January to April in 2020: a cross-sectional study

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Background: Since the first case reported in December 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused an outbreak of coronavirus disease 2019 (COVID-19) worldwide. The global case count continued to rise and the WHO declared a Public Health Emergency of International Concern (PHEIC), causing a growing risk of imported COVID-19 infection. This study aimed to provide descriptive and quantitative epidemiological characteristics of imported COVID-19 cases in China.

Methods: This cross-sectional study examined all imported COVID-19 cases in Mainland China from 22 January to 21 April 2020. Ratios, Median and percentile were used for descriptive analysis. Spearman's correlation analysis was performed between daily new imported cases in Mainland China and the country of origin. The chi-square test was used to evaluate the difference between home quarantine and compulsory centralized quarantine on native transmission.

Results: A total of 1,610 cases of COVID-19 were imported from 49 countries to 27 provincial administrative regions in China; 79.8% were from European countries and the United States of America (the USA). Before 29 March 2020, the imported cases were mainly from the USA (27.7%) and United Kingdom (UK; 42.6%). After 29 March 2020, the daily newly imported cases from Russia rapidly grew. After 12 April 2020, the number of daily newly imported cases gradually decreased and remained at a low level (12±7 cases per day). Airport entry was encouraged, and ground border crossing was limited. Among the 1,610 cases, 54.0% were in the asymptomatic incubation period on arrival in Mainland China.

Conclusions: The transmissions by imported COVID-19 were gradually and effectively curbed in Mainland China, despite a disproportionally high number of cases worldwide. Entry screening measures must be implemented universally to all inbound travelers at a point of entry or targeted to specific travel routes or to specific travelers. Compulsory centralized quarantine should be recommended in the prevention of the imported COVID-19 epidemic.

Keywords: Coronavirus disease 2019 (COVID-19); importation; prevention and control strategy; exit and entry screening; centralized quarantine

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Introduction

Since the first case reported in December 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused an outbreak of coronavirus disease 2019 (COVID-19) worldwide (1,2). The virus is transmitted person-to-person by both symptomatic and asymptomatic persons through close contact (within 6 feet) via respiratory droplets (3). The World Health Organization (WHO) declared COVID-19 a global pandemic on 11 March 2020 (4). As of 21 March 2021, over 122 million cases, including over 2.7 million deaths, have been reported worldwide (5). Mortality secondary to COVID-19 is highly variable and related to age, the severity of the disease, and comorbidities. The estimated mortality is 0.7–2% for all patients, 10% for hospitalized patients, 30–50% for patients admitted to the intensive care unit (ICU), and 37–88% for patients requiring invasive mechanical ventilation or extracorporeal membrane oxygenation (ECMO).

International travel includes mostly airports, but also seaports and land travel. The crucial co-causative role of transportation via air, sea, and land has been acknowledged rapidly, as it led to a spread to over 200 countries and regions within the first 3 months of the pandemic (as of 11 June 2020) (6). Such transportation continues to incur new infections in countries and remains one of the biggest risk factors towards second and forthcoming waves (7-9). Meanwhile, seaports and land travel are often ignored by efficacy evaluations, albeit all route channels face unprecedented and unique challenges, requiring rapid amendments in their respective triage (8,10).

As of 21 March 2021, the total number of COVID-19 cases outside China has reached over 122 million, including over 2.7 million deaths (5). Hence, the potential transmission from imported COVID-19 cases remains a major obstacle to achieving total elimination of the disease in China and to the resumption of unrestricted international transport (2). In order to interrupt any onward transmission that could potentially reignite an outbreak in China, a series of strategies were implemented, including an initially partial, followed by a total restriction, of entry/exit of travelers, as well as entry screening and compulsory quarantine with nucleic acid testing for all overseas passengers arriving with special selective permissions. Despite this positive course of countermeasures, the global case count continued to rise and the WHO declared a Public Health Emergency of International Concern (PHEIC), causing a growing risk of imported COVID-19 infection (1,11,12).

Understanding the epidemiological characteristics of imported cases is conducive to making targeted epidemic prevention policies. A study which reviewed the characteristics of imported cases in Macao during a period in 2020 found that cases were mostly returning from Europe, America or North America, corresponding to the increasing incidence of COVID-19 in these regions (13). At the same time, a modeling study simulated the risk of COVID-19 transmission in Sichuan. They found that when the diagnosis rate in foreign regions decreased, it had a positive impact on the prevention and control of the epidemic in Sichuan (14). In addition, most of the existing studies focused on imported cases at airports, while few studies reported the specific situation of imported cases at land or seaports. This could lead to gap in the formulation of quarantine policies.

This study aimed to provide descriptive and quantitative epidemiological characteristics of imported COVID-19 cases in China. The data should allow for a better understanding of the pivotal preventative attempts that could help to minimize transmission and serve as a basis for recommendations towards policy and practice on how countries can anticipate the transmission of COVID-19 from imported cases (15). We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-4553/rc).

Methods

Study design and participants

This cross-sectional study examined all imported COVID-19 cases in Mainland China from 22 January 2020 to 21 April 2020. The imported cases were diagnosed according to the unified national diagnostic criteria for COVID-19 (5th edition) (16,17). COVID-19 symptoms are defined as fever, irritability, dry cough, stuffy nose, runny nose, sore throat and diarrhea. Study reported the number of imported cases, cases' gender, age, province/cities of case reporting, specific ports which patients entered via, countries patients came from, health status at the time of arrival in Mainland China, and the time from the entry date to symptom onset. Relationship between daily new imported cases in Mainland China and the country of origin and effectiveness of home quarantine and compulsory centralized quarantine on native transmission prevention were analyzed. This study was approved by the Health Research Ethics Committee from the Shanghai

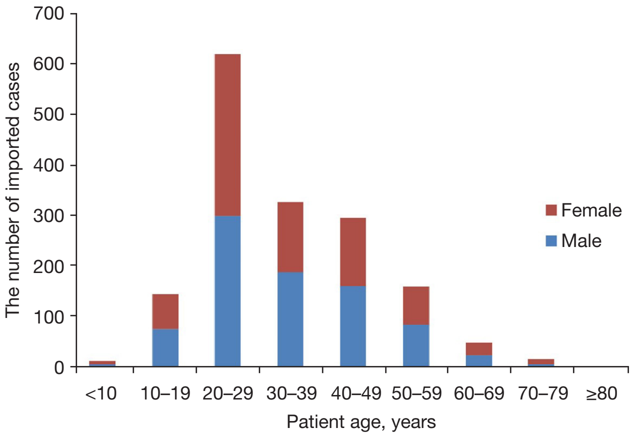

Figure 1 Demographic characteristics of imported cases in Mainland China.

East Hospital of Tongji University. The requirement for individual consent was waived by the committee. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Data collection

The data on all patients were collected from the daily updated, publicly available data pool of the National Health Commission and the Provincial Health Commissions of all provinces/cities (not including Hong Kong, Macao, and Taiwan). The data included general demographics (age, gender, nationality, etc.) and epidemiologic information (exporting country, entry date, symptom onset date, diagnosis date, entry province/city, and inbound port).

Statistical analysis

The data were collected into a central database by 2 independent investigators. Most of the analysis were descriptive. Ratios (n%) were used to describe province/city of case reporting, countries patients came from, specific ports which patients entered via, health status at the time of arrival in Mainland China. Median and percentile were used to describe age and time from entry to symptom onset of asymptomatic cases. Spearman's correlation analysis was performed between daily new imported cases in Mainland China and the country of origin. The chi-square test was used to evaluate the difference between home quarantine and compulsory centralized quarantine on native transmission. The distribution maps of the imported cases were created using ArcGIS 10.3 (Esri, Redlands, CA, USA; http://www.arcgis.com). All analyses were performed using SPSS 18.0 (IBM Corp., Armonk, NY, USA). Statistical significance was considered when two-sided P values <0.05.

Results

Demographic characteristics of imported cases in Mainland China

The first imported case was reported in Liaoning province on 22 January 2020; a total of 1,610 imported COVID-19 cases were reported in Mainland China since then (21 April 2020). Among those, no critical illness or death case occurred. The ratio of males to females was 1.08:1. The median age was 28 years (*Figure 1*).

Epidemiology of imported cases to Mainland China

The 1,610 cases were imported from 49 countries and distributed in 27 provincial administrative regions, with predominance in Heilongjiang (23.9%, 384 cases), Shanghai (18.6%, 300 cases), Guangdong (11.9%, 191 cases), Peking (10.8%, 174 cases), and Inner Mongolia (7.3%, 118 cases) (*Figure 2A,2B*). Among the 1,610 cases, 79.8% were imported from European countries and the United States of America (the USA), as follows: Russia (39.4%, 635 cases), the United Kingdom (the UK) (19.2%, 309 cases), the USA (10.2%, 164 cases), Spain (5.6%, 90 cases), and France (5.4%, 87 cases) (*Figure 2C,2D*).

The epidemiological dynamics of cases imported to Mainland China

Before 29 March 2020 (i.e., the date of border closure for incoming non-Chinese residents), most imported cases originated from the USA (27.7%) and UK (42.6%), with the first peak on 24 March 2020. The decline of daily newly imported cases from the USA and UK correlated significantly with the decreasing total daily imported cases in Mainland China (r=0.85, P<0.01 between the USA and Mainland China; r=0.82, P<0.01 between the UK and Mainland China) (*Figure 3A*).

After 29 March 2020, with the rapid growth of the daily newly imported cases from Russia, the number of daily newly imported cases gradually increased and reached a second peak on 12 April 2020. The number of daily newly imported cases to Mainland China was positively correlated

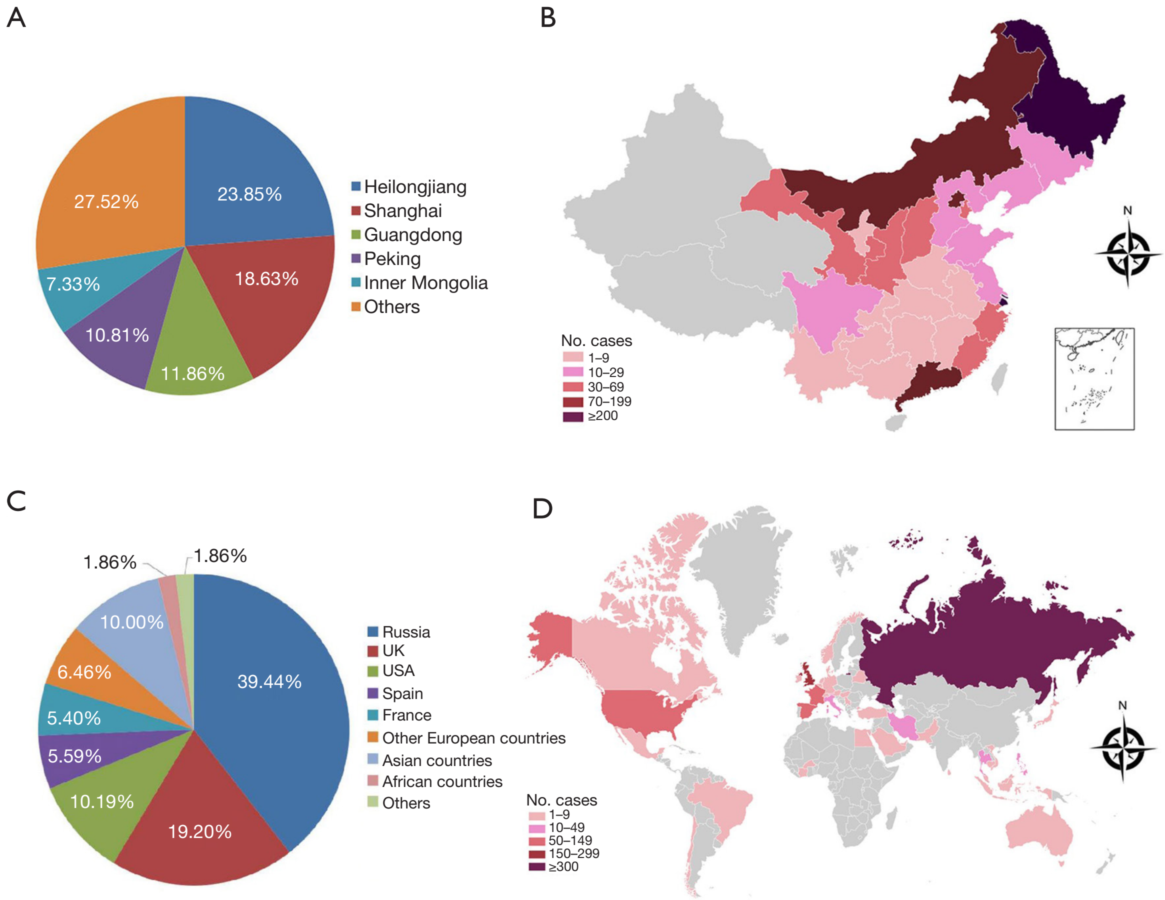

Figure 2 Spatial distribution of imported COVID-19 cases. (A) COVID-19 cases were imported to 27 provincial administrative regions in Mainland China. Of them, the most cases were in Heilongjiang province. (B) Spatial distribution of imported COVID-19 in Mainland China. The darker color means more cases. (C) The number of imported cases from Russia ranked first, 76.1% cases were imported from European countries, and 10.19% cases were imported from the USA. (D) The spatial distribution of exporting countries to Mainland China. A darker color means more cases. COVID-19, coronavirus disease 2019.

to the number of newly imported cases from Russia (r=0.69, P<0.01). After 12 April 2020, the number of daily newly imported cases gradually decreased and remained at a low level (12±7 cases per day) (*Figure 3A*).

Epidemiology of imported cases to specific ports

From 22 January 2020 to 21 April 2020, a total of 5,291,039 inbound travelers entered Mainland China via airports (n=3,761,650), land (n=1,529,042), and seaports (n=347). The proportion of imported COVID-19 cases were as follows: airports (69.5%, n=1,119), land (30.4%, n=490), and seaports (0.06%, n=1) (*Figure 3B*).

From 22 January 2020 to 14 April 2020, the weekly proportion of confirmed cases arriving via airports gradually increased, peaking in the week of 8–14 April 2020 (56.21%), subsequently declining to 20.28%. The first case imported by ground border crossing was reported on 8 March 2020. From 8 March to 7 April 2020, the proportion of confirmed imported cases via ground border crossings gradually increased, peaking in the week of 1 April to 7 April 2020 (68.6%), then rapidly declining to 0.2% (*Figure 3C*).

Asymptomatic cases and symptom onset

Among the imported cases, 54.0% were asymptomatic (incubation period) at the time of arrival in Mainland China; 26.4% (425 cases) of confirmed patients showed symptoms before they entered Mainland China, 19.6% (315 cases) showed symptoms on the entry day, and 54.0% (870 cases)

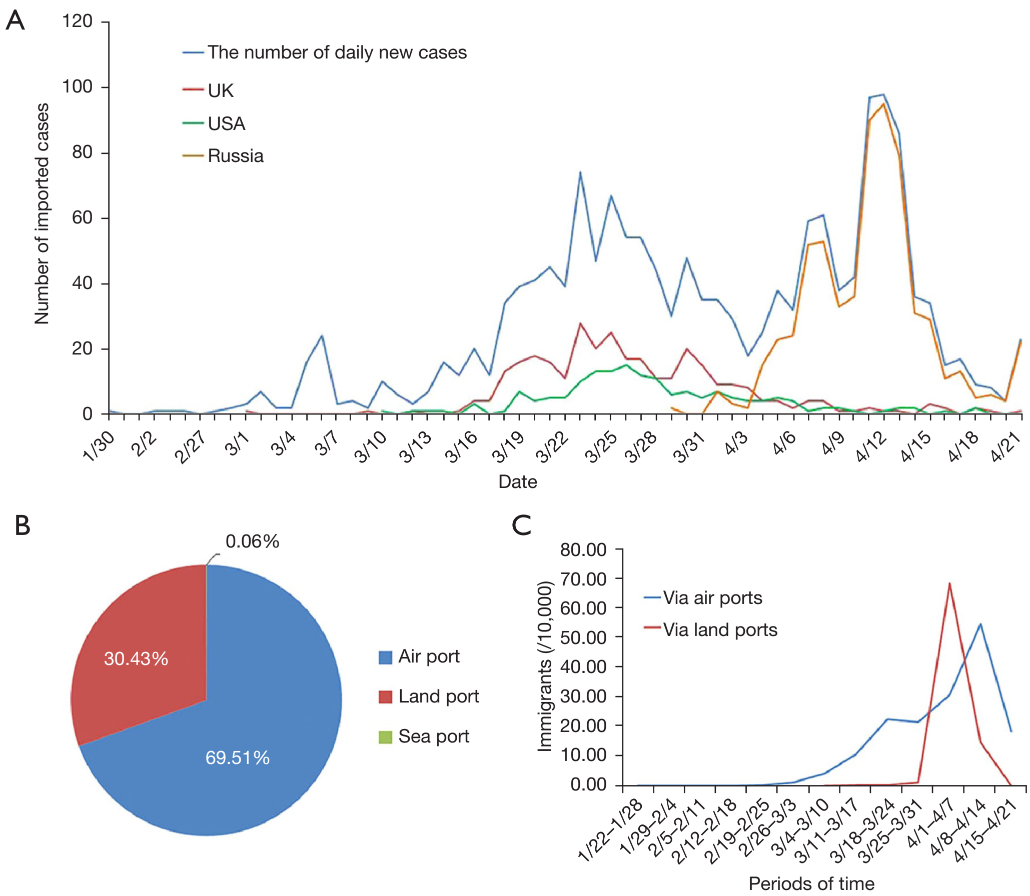

Figure 3 The dynamic changes in the proportion of imported cases. (A) The relationship of daily newly imported COVID-19 in Mainland China between importation and exportation. The number of daily newly imported cases to Mainland China was positively correlated to the number of daily newly imported cases from the USA and UK before 29 March 2020, and positively correlated to the number of daily newly imported cases from Russia after 29 March 2020. (B) The COVID-19 cases were imported to Mainland China via air (69.51%, 1,119 cases), land (30.43%, 490 cases), and seaports (<0.1%, 1 case). (C) From 22 January to 14 April, the weekly proportion of confirmed cases from airports gradually increased, peaking in the week of April 8 to April 14 (56.2%), subsequently declining to 20.3%. The first case imported by ground crossing was reported on 8 March 2020. From 8 March to 7 April, 2020, the proportion of confirmed imported cases by ground crossings gradually increased, peaking in the week of 1 April to 7 April (68.6%), then rapidly declining to 0.2%. COVID-19, coronavirus disease 2019.

after entry. Among the asymptomatic cases, the median time from the entry day to symptom onset was 2 days [95% confidence interval (CI): 3.58 to 3.99 days]. The longest time from the entry date to symptom onset was 32 days. The 95th and 99th percentile of time intervals from entry to symptom onset were 13 and 16 days, respectively (*Figure 4*).

Efficacy of compulsory centralized quarantine

By 21 April 2020, 843 cases were imported and led to 29 domestic onward transmissions via direct contact; 21 of the onward transmissions were caused by contact with imported cases at dinner, trade, and community gatherings. Consequently, the initial compulsory home quarantine was gradually replaced by compulsory centralized quarantine (designated hotels or hospitals) in all provinces/cities on different dates (Table S1). The compulsory centralized quarantine was applied to 767 imported cases. After that, only 8 domestic onward transmissions were caused by contact in accommodations, automobiles, and flights. The compulsory centralized quarantine significantly decreased the risk of onward transmission from imported cases compared with home quarantine (P<0.05).

The rate of imported cases gradually decreased in China after 12 April 2020, despite a further increase of COVID-19 cases worldwide. Before 12 April 2020, the increase of imported cases showed rapid growth in Mainland China and was positively correlated to the surge of COVID-19 cases worldwide (r=0.64, P<0.01). After 12 April 2020, the number of imported cases decreased significantly (r=0.66, P<0.01) (*Figure 5*).

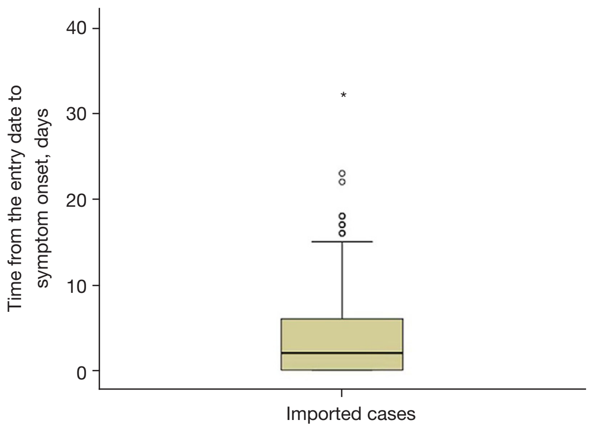

Figure 4 The analysis of time from the entry date to symptom onset. The median time, the 95th and 99th percentile from the entry day to symptom onset were 2, 13, and 16 days, respectively. The longest time from the entry date to symptom onset was 32 days.

Discussion

In response to the global surging and dispersion of cases of COVID-19, a series of strategies were implemented in Mainland China, including exit and entry screening, triage, compulsory home and centralized quarantine of all inbound travelers, and strict contact tracing. The present study showed that the transmissions by imported COVID-19 were gradually and effectively curbed in Mainland China, despite a disproportionally high number of cases worldwide.

After effective control of the domestic COVID-19 epidemic, preventing the reintroduction of SARS-CoV-2 has become the top priority in Mainland China (18). With the still ongoing mobility of individuals across borders in the early phase of the global outbreak, the rapid spread of infection resulted in a surge of the imported cases before 12 April 2020 in Mainland China. As Europe and the USA gradually became the epicenters of the disease, most imported cases originated from these regions. When COVID-19 was declared a PHEIC by WHO, the authorities in Mainland China demanded that affected countries carry out exit screening from 19 March 2020, according to the International Health Regulations (IHR), including screening of travelers for signs of infectious diseases, measurement of travelers' body temperature, and completion of a questionnaire for the presence of symptoms and/or exposure to the infectious agent (19). Similar exit screening measures have been undertaken to limit the spread of infectious disease in the past, such as for severe acute respiratory syndrome (SARS) in affected countries in 2003, plague in Madagascar in 2017, and Ebola outbreak in West Africa in 2014 and the Democratic Republic of the Congo

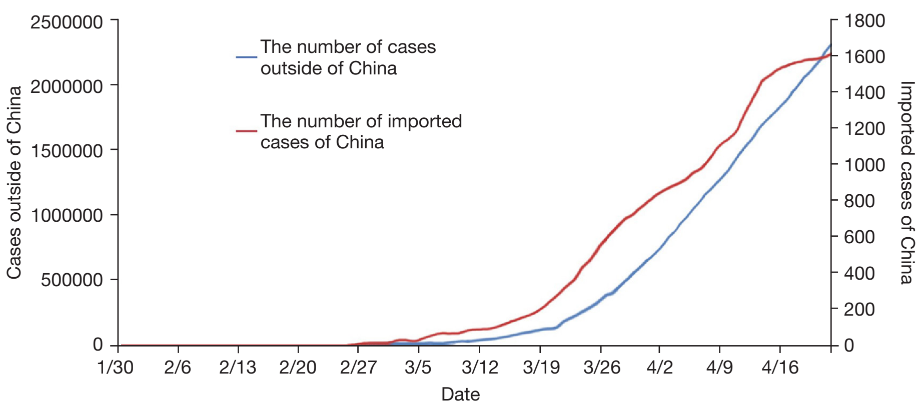

Figure 5 The importation was controlled with a series of strategies when the global epidemic was still in the surge. Before 12 April, the increase of imported cases showed rapid growth in Mainland China and was positively correlated to the surge of COVID-19 cases worldwide (P<0.01). After 12 April, the increase of imported cases significantly slowed down. COVID-19, coronavirus disease 2019.

in 2018 (20,21). The exit screening measures at borders have a discouraging effect on ill or exposed persons attempting to leave the affected countries (20,22). Nevertheless, due to inconsistent exit screening policies and detection capability among countries, the initial number of imported cases was high and correlated to the country-specific COVID-19 statistics (23,24). On 28 March 2020, China implemented a temporary ban on all foreign visitors (15). In the present study, the exporting countries gradually shifted from the UK and USA to Russia from the end of March to the beginning of April 2020. After exit screening was strengthened in Russia, the rapid rise of the imported epidemic was significantly curbed.

These observations indicate that entry screening measures must be implemented universally to all inbound travelers at a point of entry or targeted to specific travel routes (e.g., departing from an affected area) or to specific travelers (e.g., who have been in an affected area) (20,25). In the present study, the process at airports involved an initial assessment by customs with a primary screening at entry points. Symptomatic travelers would be considered suspected cases and transferred to a designated medical institution for diagnosis and treatment. The entry screening measures at land crossings were more challenging due to sparse, understaffed, and under-resourced official border entry points. Land borders were a priori characterized as "porous" (20). Therefore, entry restrictions and temporary closures were established at ground crossings when the proportion of imported cases rapidly increased from 25 March to 7 April 2020. Travelers were encouraged to enter Mainland China via airports. As a result, the proportion of imported cases via ground crossings rapidly decreased. With the combined efforts of exit screening by exporting countries and entry screening of Mainland China, the number of imported cases significantly decreased from 12 April 2020.

Gradually since the beginning of March 2020, a stricter triage—the third defense line—with a compulsory quarantine, a focused medical examination, and a nucleic acid test was implemented, as it had been shown to be efficacious in considerably reducing the impact of COVID-19 (26,27), SARS (28), the Middle East respiratory syndrome (MERS) (29), and Ebola virus outbreaks (30). The infectiousness before the onset of symptoms partially reduces the effectiveness of quarantine (31). It has been reported that the viremia in COVID-19 patients can be high enough to trigger transmission by 1–2 days before the onset of symptoms (32). In the present study, 54.0% of the imported confirmed cases were in the asymptomatic incubation period when the infected individuals arrived in Mainland China, and the median time from the entry day to symptom onset was 2 days. Asymptomatic contagious spreaders cannot be distinguished from uninfected inbound travelers. Thus, even a 90% containment of imported cases was unlikely to protect the country against the reintroduction of the virus and re-initiation of the epidemic (33). Therefore, a compulsory quarantine was enforced and controlled more strictly to reduce transmission and slow the epidemic before infectiousness was eliminated.

Home quarantine and centralized quarantine are the 2 common containment measures. Home quarantine is now becoming commonplace in many countries. However, the data from China show that the risk of community transmission during home quarantine is significantly higher than that of centralized quarantine. Due to a high transmission rate of SARS-CoV2 via multiple transmission routes, cluster infection risk significantly increased in families during the initial quarantine period (25,34,35). In addition, some individuals do not strictly adhere to the home quarantine, leading to local spreading (36). The present study showed that home-quarantined persons caused onward transmissions at dinner, trade, and community gatherings. Centralized quarantine was thus established to assure better containment (36). Onward SARS-CoV-2 transmissions were then only recorded in workers at the isolation points and passengers sharing a vehicle or a plane. The risk of onward transmissions from centralized quarantined individuals decreased significantly, allowing for better use of medical resources (36). Therefore, compulsory centralized quarantine should be recommended in the prevention of the imported COVID-19 epidemic.

According to the present study, a 13-day quarantine period was essential to the inbound persons, close to the 14-day centralized quarantine period implemented in most provinces/cities. Still, long-term quarantine was sometimes implemented by authorities because of the existence of incubation periods of COVID-19 as long as 32 days, which ruled that inbound persons must receive 14-day centralized quarantine, following another 7-day centralized quarantine and 14-day home quarantine after they returned to their place of residence (37). Although such long-term quarantine can minimize the spread of COVID-19 in the community, the risk of secondary psychological problems might significantly increase. Therefore, it may be better to shorten the quarantine period to 13 days to protect quarantined persons from mental illness.

Additional consideration should be given to the fact that asymptomatic cases with an incubation period of more than 13 days might be a risk for the community. A probability of false-negative nucleic acid tests after a 13-day quarantine period is high (the positive rate of throat swab tested by reverse transcription-polymerase chain reaction (RT-PCR) was about 30–60%, which might be due to the limitations of sample collection, transportation, and kit performance) (37,38). Therefore, contact tracing following quarantine is of high importance in the early stages of spread containment. In China, a unified health quick response (QR) code system was used for contact tracing nationwide, which tracked users' movements over 14 days, including whether users had been to virus-affected areas and had contact with confirmed or suspected cases (39). In the present study, all onward transmissions caused by imported cases were quickly controlled and contained with the help of mobility tracking provided by the health QR code. These observations indicate that individual contact tracing analysis is a useful control strategy in the early stages of onward transmissions.

This study had some limitations. As false-negatives do occur and since some infected individuals never develop COVID-19 symptoms, it is possible that some imported cases were not included in the present study. In addition, the data collected in the database are limited, which limited the scope of the present analysis.

In conclusion, in the absence of a vaccine and effective preventative or curative treatments, the elimination or control of the global COVID-19 epidemic demands alternative measures (40). This study showed that prevention and control strategies based on the epidemiological characteristics of imported cases effectively protected Mainland China against reintroducing the virus and re-initiation of the epidemic when the epidemic was still ongoing worldwide. The experience from Mainland China provides an example of effective measures to reduce transmission of imported COVID-19 cases.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-4553/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-4553/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-4553/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Health Research Ethics Committee from the Shanghai East Hospital of Tongji University. The requirement for individual consent was waived by the committee.

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Supplementary

Table S1 Starting dates of compulsory centralized quarantine in different provinces/cities.

Province/city	The starting date of compulsory centralized quarantine
Heilongjiang	21 March 2020
Shanghai	28 March 2020
Guangdong	27 March 2020
Peking	16 March 2020
Inner Mongolia	15 March 2020
Shanxi	17 March 2020
Fujian	19 March 2020
Tianjin	18 March 2020
Zhejiang	23 March 2020
Gansu	14 March 2020
Shaanxi	17 March 2020
Shandong	28 March 2020
Jiangsu	23 March 2020
Liaoning	28 March 2020
Sichuan	27 March 2020
Jilin	22 March 2020
Hebei	10 March 2020
Yunnan	27 March 2020
Henan	20 March 2020
Chongqing	26 March 2020
Ningxia	18 March 2020
Jiangxi	20 March 2020
Guangxi	20 April 2020
Anhui	15 March 2020
Hubei	17 March 2020
Hunan	16 March 2020
Guizhou	17 March 2020

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