Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Is border closure effective in containing COVID-19?

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Dear editor,

Since COVID-19 pandemic started, air travel has been subject to strict regulation and large-scale restriction to suppress the spread of SARS-CoV-2 virus. According to International Air Transport Association, the number of total passenger departures worldwide in 2020 has declined to 1975 million from 4543 million in 2019 – a 60.5% decrease that resulted in an $118 billion net loss for the industry (IATA, https://www.iatatravelcentre.com/world.php).

However, at the current stage of the pandemic, when the virus has been introduced to every populated state, the contribution of international air travel to the spread of SARS-CoV-2 is less significant than that of a large number of additional factors involved in the development of the pandemic. This observation can be proven by a simple statistical analysis. In regards to the travel restrictions on international flights, most countries can be divided into three categories: the ones that forbid entry for most foreign citizens, aside from a few exceptional cases; the states that welcome travelers from most countries, but generally subject them to a mandatory 10-14 days quarantine upon arrival; and the countries in which neither of the two types of restrictions exist. Four countries have been picked from each category, and an unpaired *t*-test was performed to compare the monthly number of COVID-19 infection cases in the period of 24 May 2021 - 24 June 2021 and determine whether these numbers show a strong correlation with the type of preventative measures that places a country in one of the three categories. The information on the travel restriction policies of each country was obtained from the IATA website. The Worldometer website was used to calculate the number of infections per 100000 people in the 31 day period from 24 May 2021 to 24 June 2021 (Worldometer, https://www.worldometers.info/coronavirus). The number of total infection cases was recorded for both dates for each country, and the difference between them was found, divided by the country's population (this data was also inferred from the Worldometer website). The calculations are shown in Table 1. The comparison of the "closed borders" countries with the ones that permit most travel, but impose a quarantine period on most passengers yielded a P value of 0.242, and a different test with the countries that do not require quarantine exhibited a value of 0.535. A *t*-test between the two categories of open border countries revealed a P value of 0.478. All of these values suggest that the difference between the monthly increases in COVID-19 patients in any of the three categories of countries is not statistically significant. This analysis is crude, and does not account for any other factors that might influence the spread of the epidemic in a particular region, being therefore insufficient to make any certain and specific conclusions. Still, even this simplistic analysis illustrates the general idea that restricting flights does not provide a state with a guaranteed protection from the pandemic, and that air travel is not the most significant factor that influences its spread. Moreover, even in the rather delicate case of avoiding the introduction of the COVID-19 into one of the few currently existing COVID-19-free countries, a modelling study shows that simple methods of prophylaxis (preliminary PCR testing, mask use and contact tracing) can ensure a low risk of COVID-19 spread for the passengers who come from the countries with a good epidemiological situation [1].

As the epidemiological situation evolves, new solutions emerge to prevent the transmission of the virus and make public spaces safer. The implementation of additional safety measures, such as vaccines, PCR testing for the passengers, use of medical masks, and social distancing would make it possible to increase the number of flights, eventually reaching the pre-pandemic numbers of passenger departures.

One of the developments that has already had a massive impact on the dynamic of the pandemic progression in some countries is the introduction of vaccines against COVID-19 to the larger population. The Moderna vaccine, and Pfizer/BioNTech vaccine (BNT162b2) were proven to have 94.1% [2] and 95% [3] efficacy respectively. These vaccines, as well as several others could shift the pandemic itself into a milder, more controllable state if sufficient distribution among the population is achieved. Such is the case of Israel, where by June 19, 2021, 54% of the country's population was vaccinated and the infection rates decreased significantly [4]. Vaccination decreases the risk of contracting COVID-19 and is advised by Centers for Disease Control and

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Table 1
Examples of COVID-19 cases in the time period of 24.05.2021–24.06.2021 (Worldometer, https://www.worldometers.info/coronavirus).

Country	Total COVID-19 cases on 24.05.2021	Total COVID-19 cases on 24.06.2021	Total population	Number of COVID-19 cases per 100000 people
Myanmar	143267	150714	54771939	13.61
Papua New Guinea	15817	17079	9119023	13.84
Libya	183592	191660	6965209	115.83
Estonia	128669	130898	1327411	167.92
Belarus	368978	413139	9446275	467.50
Latvia	131079	137110	1866132	323.18
Uzbekistan	98657	107708	33957540	26.65
Egypt	254984	297184	104292928	40.46
Russia	5009911	5388695	145995901	259.45
Greece	391181	419909	10373534	267.94

Red: closed border; Green: open border but quarantine; Blue: open border and no quarantine.

Prevention to all passengers travelling by air (CDC, https://www.cdc.gov/coronavirus/2019-ncov/travelers). Providing a document that confirms the receipt of both doses of the vaccine should therefore be primarily for the passenger to be regarded as safe and suitable for transportation with a higher degree certainty. While the current levels of vaccine distribution in most countries do not allow the airline companies to require a confirmation of vaccination from all passengers, many governments require a negative PCR test certificate to cross the border [5]. It is possible to set up more commercial testing companies to make PCR testing more accessible, and install express testing laboratories in airport buildings. In addition, infected passengers could be detected at the airport by a number of screening methods. The widely employed temperature screening method was shown to be ineffective against COVID-19, as a large number of carriers do not develop a fever [6]. On the other hand, the Helsinki-Vantaa airport in Finland successfully employs dogs to detect the virus, and this unorthodox method was proven to possess a high degree of sensitivity. [7]. Finally, the implementation of the appropriate hygiene measures and social distancing makes the aircraft cabin a relatively safe environment with low chances of viral transmission. Aircraft cabins commonly contain HEPA filters [5]. Moreover, many companies conduct a disinfection of the cabin after each flight, and virtually all flights require the passengers to wear protective masks.

The list of possible solutions to the question of flight safety during the COVID-19 pandemic is not limited to the solutions listed above, and even less so – to the particularities of their implementation. Other types of COVID-19 tests are being developed that could provide a quick on-spot diagnosis, though to be implemented in such a manner, the test should be both accurate and suitable for mass-production. Definite protocols for dealing with infected passengers and disinfection standards need to be established by companies, taking the research that is being conducted in that area into consideration. Airline companies could, for example, use nanotechnology for disinfection, or employ PCR screening, or have robots doing service in the cabin or use materials with anti-viral properties.

All of these measures, both currently implemented and only undergoing development, constitute a solid argument for the increase in the amount of flights in the near future. To conclude, the prospective and already existing data suggests that closing the border for air travel does not result in a considerable decline in the number of infection cases. At the same time, implementing a policy that requires the passengers to provide a proof of vaccination and a negative PCR testing results, as well as enforcing a strict sanitary regime in the aircraft cabin in the environment where a significant proportion of the population underwent vaccination might ensure the safety of the passengers to allow airline companies to increase the number of flights, and recover from the financial losses that shook the industry in 2020.

Data statement

Data available on reasonable request from authors.

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Authors' contributions

Yingqiu Xie proposed the idea and question, designed the project and wrote paper. Leya Timur collected data, analzyed data, made table, searched references and wrote paper.

Declaration of competing interest

There is no conflicts of interest to declare.

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