



ECDC

<Unit/Section>

Potential effectiveness of entry and exit screening against 2019_nCoV

27 January 2020

Background

Entry screening has been proposed as a means to identify travelers with the novel coronavirus (2019_nCoV), thus preventing the introduction of the virus to European cities. The potential benefit of introducing entry screening is not only a reduction in the overall number of imported cases but also, importantly, an increased chance of delaying the start of an epidemic within a country's borders. (1)

There are three potential types of imported cases (Figure 1):

- symptomatic cases missed by exit screening
- cases that are in the incubation period (latent) at take-off but who develop symptoms in-flight
- cases resulting from on-board transmission (these will not be identified by entry screening since

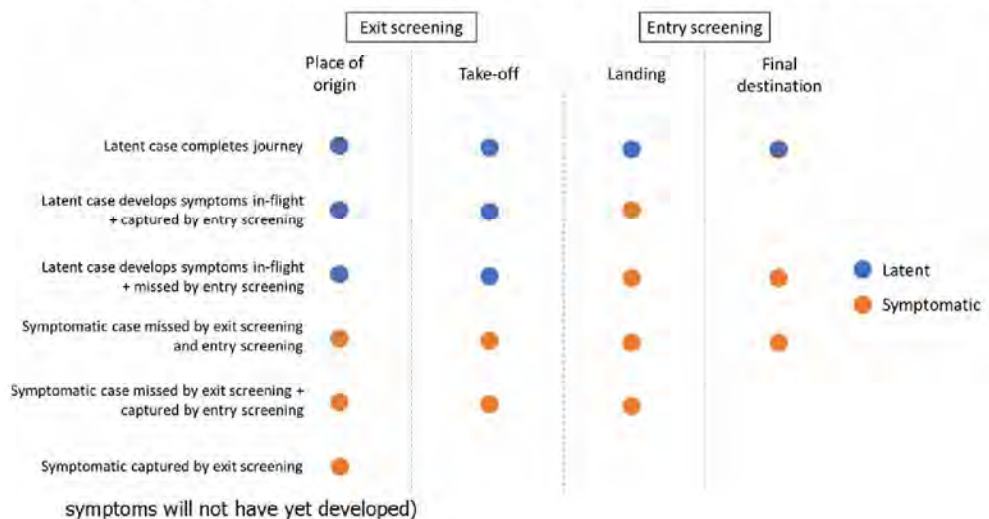


Figure 1 Potential scenarios for importation of 2019_nCoV cases in the context of exit and entry screening

This paper presents a modelling analysis to estimate the proportion of travelling cases that will be admitted to their destination country, whether in a latent or symptomatic state, and the proportions that will be detected by exit and entry screening. It is currently difficult to estimate the overall risk of importation, due to the extent of behavioural change in China, but current estimates by Colizza et al. can be found at: https://www.epicx-lab.com/uploads/9/6/9/4/9694133/inserm_2019ncov-importation-risk_20200126.pdf

Methods

Since the number of cases leaving China is unknown, we estimate the proportion of cases that would be detected by exit and entry screening on each direct flight route to Europe from the four main affected cities: Beijing, Shanghai, Guangzhou and Hangzhou. We exclude Wuhan, which has cancelled all flights. Data on flight routes and flight duration was sourced from <https://www.flightconnections.com>.

The probability that a case will be detected by entry screening depends on:

1. The probability that the case was in the symptomatic state at the airport of origin. We estimated this proportion by back-calculating date of infection from the reporting date of confirmed cases, fitting an exponential growth model, and then projecting the outbreak forwards in time. (Further details can be found in Appendix C)
2. The effectiveness of exit screening in identifying a symptomatic case. We modelled two scenarios: 80% and 20%.
3. The probability that a latent case will develop symptoms in-flight. We followed the method of Pitman et al. (2). (Further details can be found in Appendix C)
4. The effectiveness of entry screening in identifying a symptomatic case. Again, we modelled two scenarios: 80% and 20%.

We conducted bootstrap sampling (100 replications of $n=1000$ cases) to give a mean and 95% credible intervals for the proportions of cases detected by screening.

Results

The effectiveness of exit and entry screening is presented for the five European cities with the highest exportation risk from China (Colizza et al, see above), assuming the test efficacy for symptomatic cases to be 80% (Table 1) and 20% (Table 2). Results for all direct flights from Beijing, Shanghai, Guangzhou and Hangzhou to the EU/EEA are presented in Appendix A.

In the higher screening efficacy scenario (80%), only 1% (95% credible interval (CI): 1% - 2%) of cases will be admitted to their destination country in a symptomatic state. However, depending on the flight duration, between 75% (95% CI: 73% - 78%) and 79% (95% CI: 76% - 82%) of the cases will pass through both exit and entry screening and arrive at their final destination in a latent state. In this scenario, between 15% and 18% of cases attempting travel will be prevented from boarding and approximately 5% will be detected at their arrival airport.

In the lower screening efficacy scenario (20%), the proportion of cases reaching their final destination in a symptomatic state is much higher: 15% (95% CI: 13% - 17%) to 17% (95% CI: 15% - 20%), depending on the duration of the flight. As in the higher efficacy scenario, the proportion of cases entering the country in the latent state is 74% (95% CI: 71% - 77%) and 77% (95% CI: 74% - 79%). Roughly, 4% of cases are prevented from travelling and 4% of cases are detected on arrival.

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Origin	Destination	Passenger outcome			
		Latent entry	Symptomatic entry	Did not travel	Quarantined on entry
Beijing	Amsterdam	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.06)
Beijing	Frankfurt	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.06)
Beijing	London	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Beijing	Madrid	0.75 (0.72, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Milan	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Paris	0.75 (0.72, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Guangzhou	London	0.79 (0.76, 0.82)	0.01 (0.01, 0.02)	0.15 (0.13, 0.17)	0.05 (0.03, 0.06)
Guangzhou	Paris	0.79 (0.76, 0.82)	0.01 (0.01, 0.02)	0.15 (0.12, 0.17)	0.05 (0.04, 0.06)
Shanghai	Frankfurt	0.76 (0.74, 0.78)	0.01 (0.01, 0.02)	0.17 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	London	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	Madrid	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.06 (0.04, 0.07)
Shanghai	Milan	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.07)
Shanghai	Paris	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)

Table 1 Proportion of cases prevented from entering a European city following a direct flight leaving China on 28th January 2020 if both exit and entry screening have 80% efficacy in identifying symptomatic cases.

Origin	Destination	Passenger outcome			
		Latent entry	Symptomatic entry	Did not travel	Quarantined on entry
Beijing	Amsterdam	0.76 (0.74, 0.79)	0.16 (0.14, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Beijing	Frankfurt	0.76 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	London	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Beijing	Madrid	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Milan	0.76 (0.74, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Paris	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Guangzhou	London	0.74 (0.71, 0.76)	0.17 (0.15, 0.2)	0.05 (0.03, 0.06)	0.04 (0.03, 0.06)
Guangzhou	Paris	0.74 (0.71, 0.77)	0.17 (0.15, 0.2)	0.05 (0.03, 0.06)	0.04 (0.03, 0.06)
Shanghai	Frankfurt	0.77 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	London	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Madrid	0.76 (0.73, 0.79)	0.16 (0.14, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Milan	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Paris	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)

Table 2 Proportion of cases prevented from entering a European city following a direct flight leaving China on 28th January 2020 if both exit and entry screening have 20% efficacy in identifying symptomatic cases.

In the increasing phase of an outbreak, a high proportion of cases has been infected recently, affecting the probability that any given case will develop symptoms during the flight. The analysis was performed for five possible dates of take-off (27th January 2020 – 31st January 2020). Over this timeframe, only very slight changes are predicted in the proportions of cases entering a European city: for example, on flights from Beijing to Paris, the proportion of cases prevented from boarding the plane increases from 17.5% (95% CI:

15% - 20%) to 18.4% (95% CI: 16% -21%). Figure 2 shows the proportions over time for flights from Beijing, given exit and entry screening efficacy of 80%. Equivalent plots are shown for other flight routes in Appendix B.

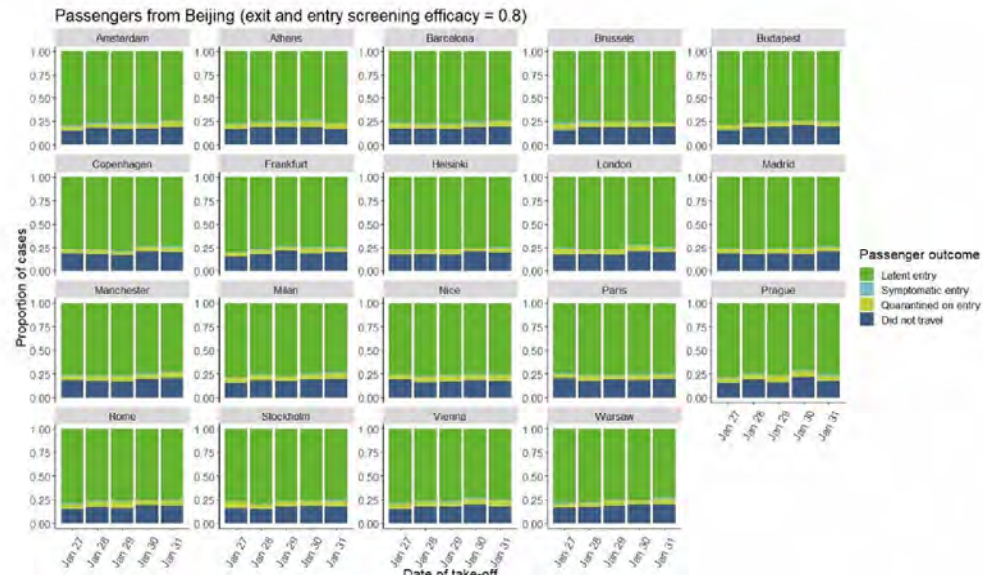


Figure 2 Proportion of travelling cases on direct flights from Beijing to Europe who would be captured by exit and entry screening with an efficacy of 80% in identifying a symptomatic case.

Discussion

- Even if both exit and entry screening have an efficacy of 80% in identifying a symptomatic case, between 76% and 80% of travelling cases will enter their destination country unidentified. Roughly 98% of these will still be in the incubation period on arrival.
- In the decreasing phase of an outbreak, a higher proportion of cases will have been infected for a longer time. In this period, a case will be more likely to develop symptoms in-flight and the effectiveness of entry screening will be higher. Entry screening could be re-evaluated at the end of the outbreak.
- We assumed no in-flight transmission. Even if such transmission does occur, secondary cases would not develop symptoms before the end of the flight. However, the proportion of latent cases passing through entry screening would then be higher. An alternative approach would be to quarantine all passengers on the flight but this is unlikely to be cost-effective given that the specificity of the test is low.
- We assumed that symptomatic cases are as likely to attempt travel as those with latent infection. This is unlikely but means that our estimates of the proportion of cases being admitted as latent is conservative.
- An alternative benefit of entry screening is in delaying the start of an epidemic within a country's borders (1). The extent of this delay is dependent on the effectiveness of entry screening i.e. the proportion of all arriving cases that are detected, and the case doubling time. If entry screening is 90%

effective, and the doubling time of the epidemic is five days, screening will delay the onset of an epidemic by 17 days (Jacco Wallinga, personal communication).

- Previous studies have shown limited effectiveness of entry screening for SARS coronavirus, whether by temperature scanning or symptom identification methods. (3, 4).

Acknowledgements: (10)(2e), (10)(2e), (10)(2e) and (10)(2e) for helpful suggestions

Appendix A

Table A1 Proportion of cases prevented from entering a European city following a direct flight leaving China on 28th January 2020 if both exit and entry screening have 80% efficacy in identifying symptomatic cases.

Origin	Destination	Passenger outcome			
		Latent entry	Symptomatic entry	Did not travel	Quarantined on entry
Beijing	Amsterdam	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.06)
Beijing	Athens	0.75 (0.72, 0.78)	0.01 (0, 0.02)	0.18 (0.15, 0.21)	0.05 (0.04, 0.07)
Beijing	Barcelona	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.07)
Beijing	Brussels	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.07)
Beijing	Budapest	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.06)
Beijing	Copenhagen	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.03, 0.06)
Beijing	Frankfurt	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.06)
Beijing	Helsinki	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.03, 0.06)
Beijing	London	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Beijing	Madrid	0.75 (0.72, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Manchester	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Milan	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Nice	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.21)	0.05 (0.04, 0.07)
Beijing	Paris	0.75 (0.72, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Beijing	Prague	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.06)
Beijing	Rome	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.07)
Beijing	Stockholm	0.76 (0.74, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.06)
Beijing	Vienna	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.07)
Beijing	Warsaw	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.05 (0.04, 0.06)
Guangzhou	Amsterdam	0.79 (0.77, 0.82)	0.01 (0, 0.02)	0.15 (0.13, 0.17)	0.05 (0.03, 0.06)
Guangzhou	Helsinki	0.8 (0.77, 0.82)	0.01 (0, 0.02)	0.15 (0.13, 0.17)	0.05 (0.03, 0.06)
Guangzhou	London	0.79 (0.76, 0.82)	0.01 (0.01, 0.02)	0.15 (0.13, 0.17)	0.05 (0.03, 0.06)
Guangzhou	Paris	0.79 (0.76, 0.82)	0.01 (0.01, 0.02)	0.15 (0.12, 0.17)	0.05 (0.04, 0.06)
Guangzhou	Rome	0.79 (0.76, 0.82)	0.01 (0.01, 0.02)	0.15 (0.13, 0.17)	0.05 (0.04, 0.06)
Hangzhou	Amsterdam	0.74 (0.71, 0.76)	0.01 (0.01, 0.02)	0.19 (0.17, 0.22)	0.06 (0.04, 0.07)
Hangzhou	Rome	0.73 (0.71, 0.76)	0.01 (0.01, 0.02)	0.2 (0.17, 0.22)	0.06 (0.04, 0.07)
Shanghai	Amsterdam	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	Barcelona	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.06 (0.04, 0.07)
Shanghai	Budapest	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	Copenhagen	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.06)
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Shanghai	Madrid	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.16, 0.2)	0.06 (0.04, 0.07)
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Shanghai					
Shanghai	Munich	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
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Shanghai	Prague	0.76 (0.73, 0.79)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	Rome	0.75 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.21)	0.05 (0.04, 0.07)
Shanghai	Stockholm	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)
Shanghai	Vienna	0.76 (0.73, 0.78)	0.01 (0.01, 0.02)	0.18 (0.15, 0.2)	0.05 (0.04, 0.07)

Table A2 Proportion of cases prevented from entering a European city following a direct flight leaving China on 28th January 2020 if both exit and entry screening have 20% efficacy in identifying symptomatic cases.

Origin	Destination	Passenger outcome			
		Latent entry	Symptomatic entry	Did not travel	Quarantined on entry
Beijing	Amsterdam	0.76 (0.74, 0.79)	0.16 (0.14, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Beijing	Athens	0.76 (0.74, 0.79)	0.16 (0.14, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Barcelona	0.76 (0.74, 0.78)	0.16 (0.14, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Beijing	Brussels	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Budapest	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Copenhagen	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Frankfurt	0.76 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Helsinki	0.77 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	London	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Beijing	Madrid	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Manchester	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Milan	0.76 (0.74, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
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Beijing	Vienna	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Beijing	Warsaw	0.77 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Guangzhou	Amsterdam	0.73 (0.71, 0.76)	0.17 (0.15, 0.2)	0.05 (0.04, 0.06)	0.04 (0.03, 0.05)
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Shanghai	Frankfurt	0.77 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Helsinki	0.77 (0.74, 0.8)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	London	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Madrid	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Manchester	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Milan	0.76 (0.74, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Nice	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Paris	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Prague	0.76 (0.73, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Rome	0.76 (0.73, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Stockholm	0.76 (0.74, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Vienna	0.76 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Warsaw	0.77 (0.74, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)

Potential effectiveness of entry and exit screening against
2019 nCoV

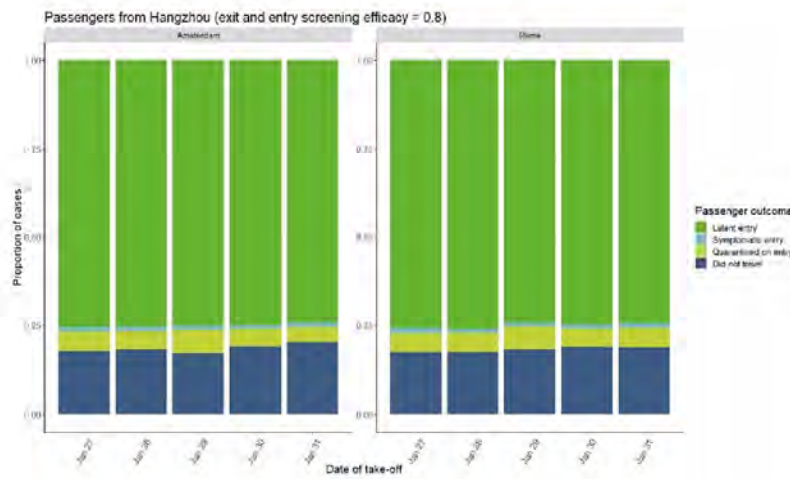
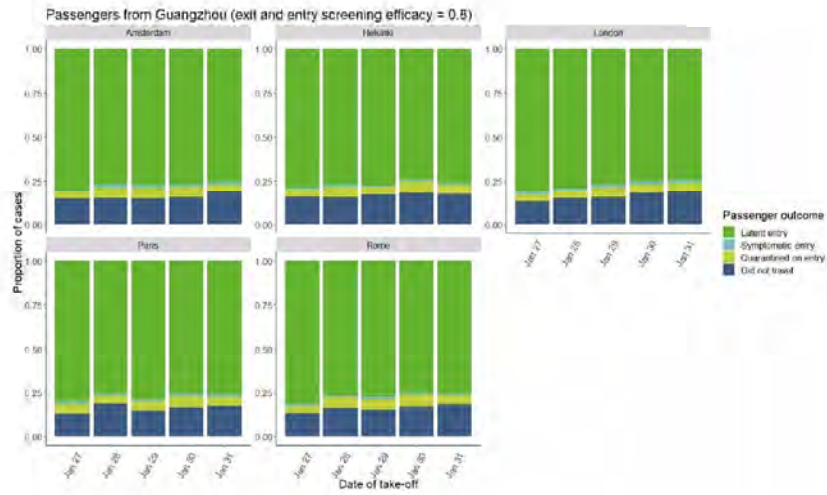
7/15

Shanghai					
Shanghai	Milan	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Munich	0.77 (0.75, 0.79)	0.15 (0.13, 0.17)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Paris	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Prague	0.76 (0.74, 0.79)	0.16 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Rome	0.77 (0.74, 0.79)	0.15 (0.13, 0.18)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)
Shanghai	Stockholm	0.77 (0.74, 0.8)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.03, 0.05)
Shanghai	Vienna	0.77 (0.74, 0.8)	0.15 (0.13, 0.18)	0.04 (0.03, 0.05)	0.04 (0.02, 0.05)

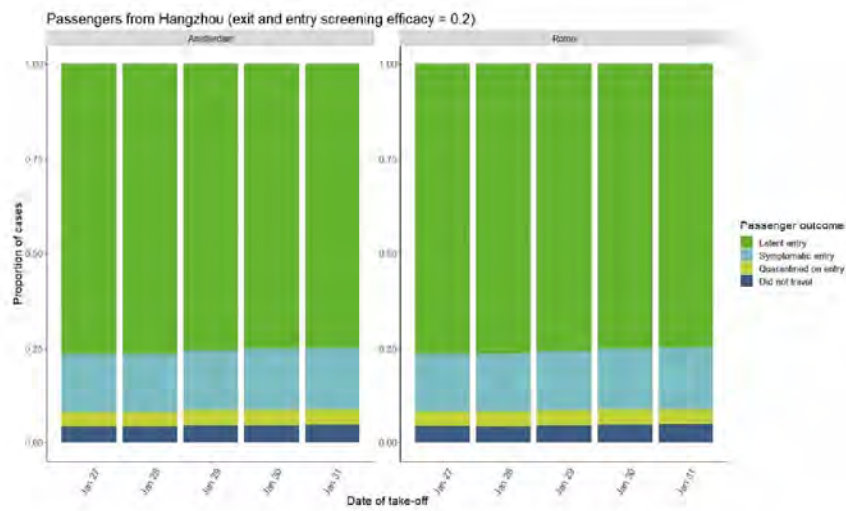
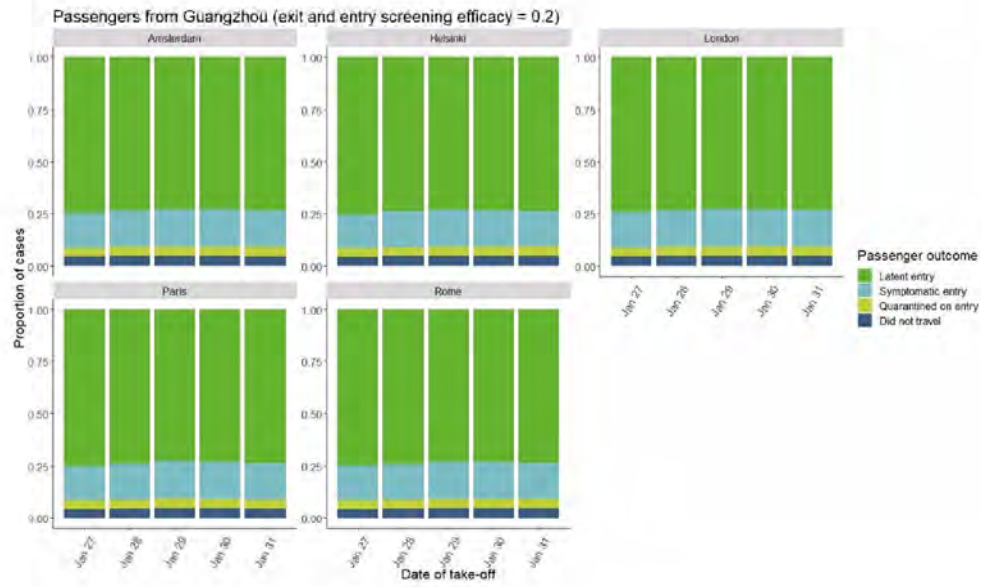
Appendix B

Proportion of travellers on direct flights from China to Europe who will be captured by entry and exit screening









Appendix C

In order to estimate the proportion of cases that are in the latent phase on the date of flying, we back-calculate the distribution of date of infection of confirmed cases by resampling reported cases ($n = 1,000,000$ samples) and then subtracting sampled values from the reporting period and incubation period, fit an exponential growth model and then forecast the number of incident cases over a time period of 5 days..

The incubation period (the lag between the date of infection and the date of symptom onset) is modelled as a Gamma distribution with shape parameter = 7 days and scale parameter = 1 day (Figure C1a). The delay in reporting (the lag between the date of symptom onset and the date of reporting a confirmed case) is modelled as a Gamma distribution with shape parameter = 2 days and scale parameter = 1 day (Figure C1b).

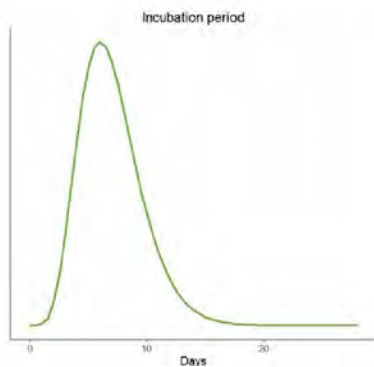


Figure C1a Distribution of incubation period: Gamma (shape = 7, scale = 1)

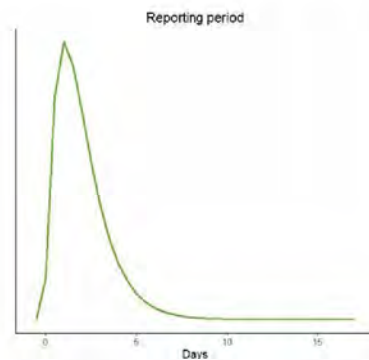


Figure C1b Distribution of reporting lag: Gamma (shape = 2, scale = 1)

The exponential growth model was fitted using least squares approximation to the inferred date of infection for aggregated data on confirmed cases from all China. The model fit for Hubei (Wuhan), Beijing, Shanghai, Guangdong (Guangzhou) and Zhejiang (Hangzhou) is shown in Figure C2.

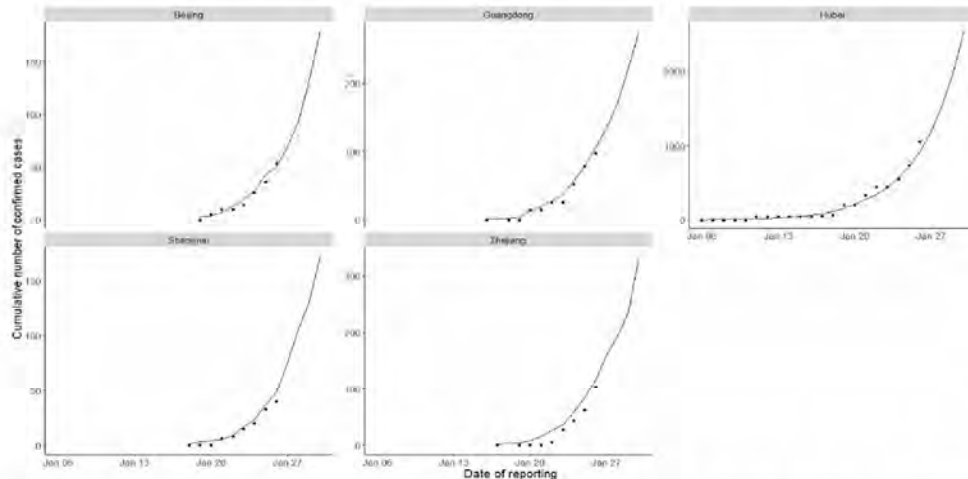


Figure C2 The fit of the exponential growth model to data on confirmed cases from all China up to 26th January 2020

Forecasts from the exponential model were used to estimate the proportion of latent cases from each source city on the date of flight.

We developed an individual-based model to estimate the proportion of cases that would be detected by exit screening, develop symptoms in-flight or being detected by entry screening.

The probability of developing symptoms in-flight given mean direct flight duration (d) and time since infection (t) is given by:

$$P_{t,d} = \frac{G([t+d], \alpha, \beta) - G(t, \alpha, \beta)}{1 - G(t, \alpha, \beta)}$$

where $G(t, \alpha, \beta)$ is the cumulative gamma distribution.

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