2019-nCoV importation risk to Europe

Report #3 [Report #2] [Report #1]

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NOTE: This is a brief report with preliminary estimates based on limited information available. Updates will follow as the situation evolves.

28/01/2020 (DATA UP TO 27/01/2020)

CURRENT SITUATION

Starting December 2019, cases of pneumonia of unknown etiology were reported in the city of Wuhan, in the province of Hubei in China [1]. The infective pathogen was later identified to be a novel coronavirus, called 2019-nCoV [2].

As of 26/01/2020, a total of 1,988 confirmed cases were reported from China [3]. The main affected area is in the province of Hubei, but other 32 provinces reported confirmed cases as of 27/01/2020 [4].

Forty-one travel-related cases were exported out of China as of 27/01/2020, with 27 cases (66%) imported in Asia, 6 (15%) in North America, 5 (12%) in Oceania, and 3 (7%) in Europe [3,5-7]. In Europe, 3 cases were imported in France. They were confirmed on 24/01/2020, with travel dates on 18/01/2020 (2 cases) and 22/01/2020 (1 case). One case was confirmed in Germany with no history of travel to China but contacts with a Chinese guest visiting his company [8]. In a step to contain the viral spread, Chinese authorities enforced travel restrictions in the province of Hubei starting on 23/01/2020 (3AM Central European Time), including a complete ban on international flights [9].

AIM & METHODS

Following the confirmation of 1 case in Germany on 27/01/2020, we update our estimates of the risk of importation of 2019-nCoV cases to Europe from infected areas in China by air travel (see report #2).

Due to the travel ban put in place in the province of Hubei, we consider as possible seeds of case exportation out of China the cities predicted to be at high risk (see map) due to their internal connectivity to Wuhan. These cities were identified in a 25/01 report by the University of Southampton that analyzed de-identified and aggregated domestic population movement data (2013-2015) derived from Baidu Location-Based Services to estimate the risk of 2019-nCoV spread within Mainland China around the New Lunar Year migration [10]. They were found to be highly correlated with the number of reported cases in the corresponding provinces [4,10].

This seeding further expands the multi-source seeding we considered in our report #1 to account for the evolving situation. For sensitivity, we also tested the additional inclusion of Wuhan in the multi-source seeding.

Map of Chinese provinces color coded according to the number of cases [4]. The cities selected for the multi-source seeding are shown with black dots [10]. Wuhan (grey dot) is not considered as a seed due to the current travel ban.

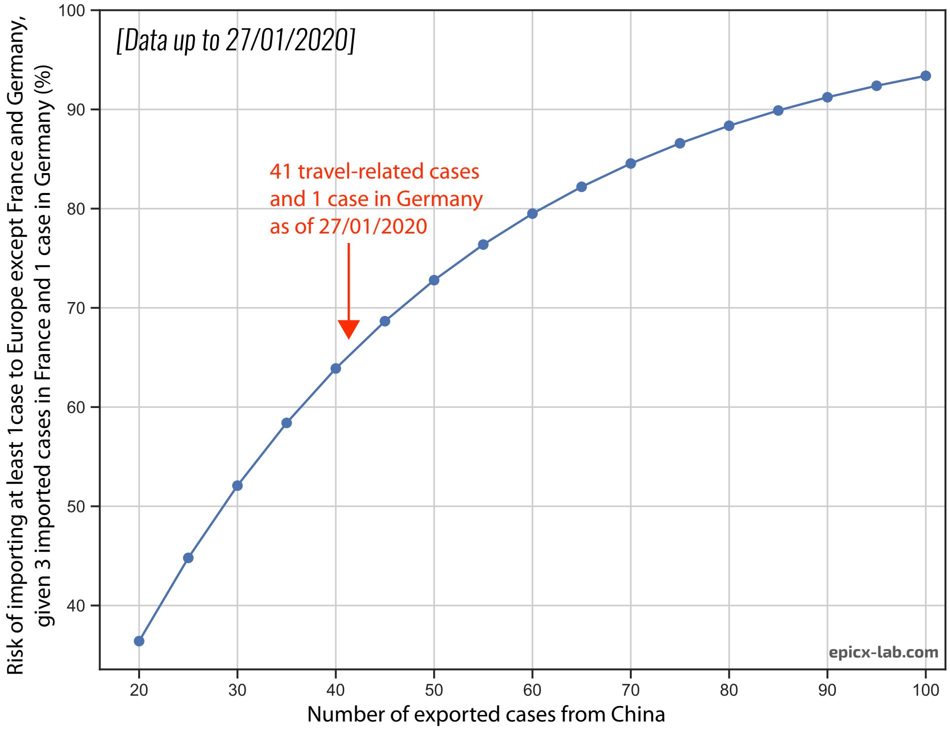
We estimate the risk of *importation to Europe except France* as the probability that Europe (France and Germany excluded) imports travel-related cases from China, conditioned to the observation of 3 cases imported to France and 1 case confirmed in Germany. The computation of the risk to European countries is based on estimates from the platform EpiRisk [11] and accounts for origin-destination air travel flows of January from 2019 OAG database of the GLEAM Project [11-13]. The Appendix provides the details of the computation of the conditioned probability. We estimate the risk for a varying number of exported cases from China, given the current difficulty of assessing the likelihood of exportation from China due to limited data.

We then provide a color-coded map of Europe to report the country-specific risk of importation if a case is imported to Europe.

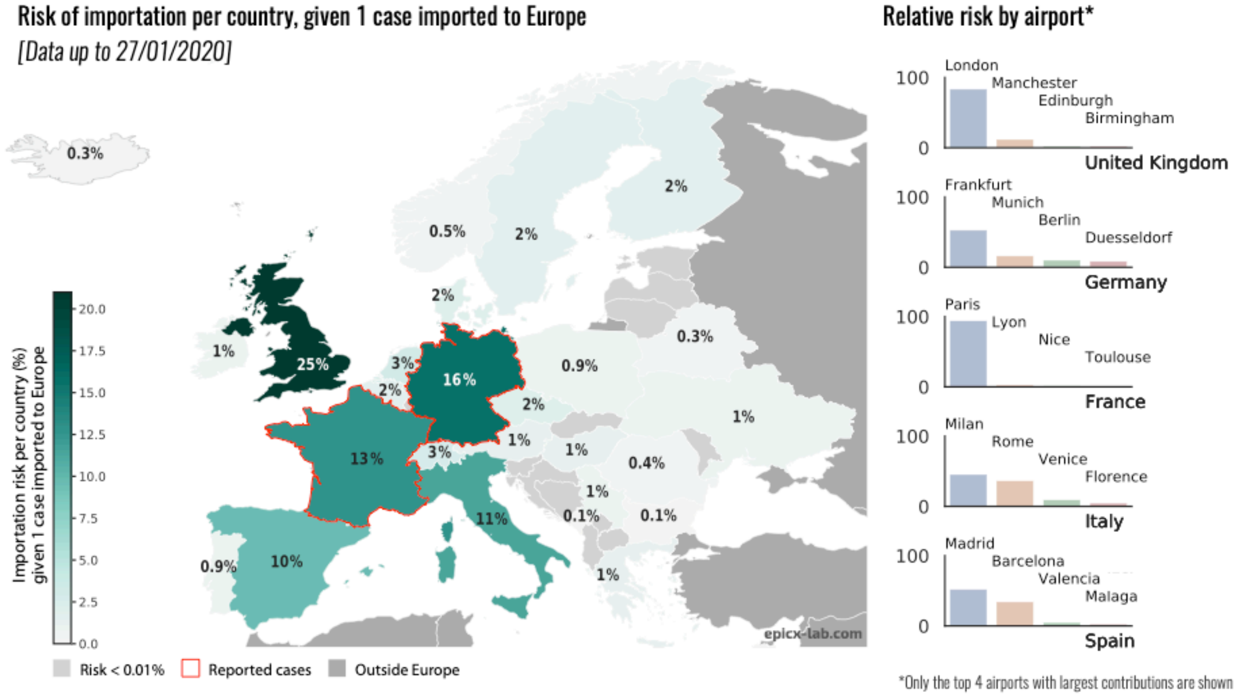
Updates from report #2:

- The risk of importation to Europe is conditional to the 3 cases imported in France [3] and 1 case confirmed in Germany [8].
- Data are updated to 27/01/2020

ESTIMATED IMPORTATION RISK FROM INFECTED PROVINCES IN CHINA



The probability that at least 1 case is imported to Europe except France and Germany, given the 3 imported cases reported in France and 1 confirmed case in Germany, is high. It is estimated to be more than 64% for the number of travel-related exportations from China reported so far (41 travel-related and one confirmed case in Germany). The probability becomes larger than 80% if 60 cases are exported from China.



In the event that 1 travel-related case is imported to Europe, the risk of importation is highest in the UK (25%) Germany and France, which already imported cases, rank second and third with a probability of 16% and 13% to receive another case, respectively. Italy (11%) and Spain (9.5%) rank as fourth and fifth in the risk.

For the top 5 countries at higher risk of importation, histograms display the airports that are most likely to import cases (only the 4 top airports are displayed for the sake of visualization). In some countries, importations are likely to occur at multiple airports (e.g. Germany and Italy), whereas in others the risk is mostly concentrated in airports serving the capital city (e.g. in the UK, where London contributes to 83% of the risk, and in France, where Paris contributes to 94% of the risk).

The estimates account for the travel ban imposed in the province of Hubei. Including travel flows from Wuhan, to account for cases that may have flown before the travel ban and are not yet detected, does not alter the estimations.

CONCLUSIONS

France reported on 24/01/2020 the importation of three 2019-nCoV confirmed cases from China, and Germany confirmed its first case on 27/01/2020 with no history of travel to China. They are still the first and only cases confirmed in Europe. We estimate that the risk of importation of at least 1 case to Europe but France and Germany is high. It is larger than 80% if 60 travel-related cases are exported from China. . The top three countries at highest risk are the UK, Germany, and France (confirming our previous estimates and those reported by other groups [10,12,14]), with the latter two already reporting cases. It is possible that cases have already been imported in other European countries besides France and Germany, and that they have not been reported yet due to a delay from importation to confirmation. For example, all 3 cases imported to France were confirmed on 24/01/2020, with 2 traveling on 18/01/2020 and 1 on 22/01/2020.

Our results are based on available data and estimates of the affected provinces in China and account for origin-destination travel fluxes from these provinces, as well as the travel ban enforced in the Hubei province. However, estimates are sensitive to different health-seeking behaviors that infected travelers may have, and to the active surveillance practices put in place in European countries. We did not provide estimates of the expected number of imported cases per country, as this depends on the number of travel-related exported cases from China, a variable that is still hard to assess at this early stage.

Risk maps will need to be rapidly updated as the outbreak situation evolves.

APPENDIX – CONDITIONED PROBABILITY

Let us define:
n: number of cases exported from China;
m: number of countries in Europe with detected cases;
$\vec{x}$: m-dimensional vector encoding the number of cases in each European country with detected cases;
$c = \sum_{j=1}^{m} x_j$: number of detected cases imported to Europe;
$\vec{p}$: m-dimensional vector encoding the importation probabilities in each European country with detected cases;
$g = \sum_{j=1}^{m} p_j$: probability of importing to any of the m countries;
q: probability of importing to Europe except the m countries;
y: cases potentially imported to Europe except the m countries.

We need $P(y|\vec{x})$.We decompose it as follows, and compute separately the numerator and the denominator:

$$P(y|\vec{x}) = \frac{P(y, \vec{x})}{P(\vec{x})}.$$

Both numerator and denominator come from multinomial distributions. The distribution for the denominator is $(m+1)$-dimensional: probability of importing to one of the m countries, and probability

to import somewhere else. The distribution for the numerator is $(m+2)$-dimensional: probability of importing to one of the m countries, to import somewhere to Europe except the m countries, and probability to import somewhere else.
Putting these together, we get

$$P(y|\vec{x}) = \binom{n-c}{y}\left(1-\frac{q}{1-g}\right)^{n-c}\left(\frac{q}{1-g-q}\right)^{y}.$$

Setting $y=0$, we can compute the probability of having at least one case as

$$P(y>0|\vec{x}) = 1-\left(1-\frac{q}{1-g}\right)^{n-c}.$$

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