



## Short Communication

# Preliminary estimation of the novel coronavirus disease (COVID-19) cases in Iran: A modelling analysis based on overseas cases and air travel data



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## ABSTRACT

As of March 1, 2020, Iran had reported 987 novel coronavirus disease (COVID-19) cases, including 54 associated deaths. At least six neighboring countries (Bahrain, Iraq, Kuwait, Oman, Afghanistan, and Pakistan) had reported imported COVID-19 cases from Iran. In this study, air travel data and the numbers of cases from Iran imported into other Middle Eastern countries were used to estimate the number of COVID-19 cases in Iran. It was estimated that the total number of cases in Iran was 16 533 (95% confidence interval: 5925–35 538) by February 25, 2020, before the UAE and other Gulf Cooperation Council countries suspended inbound and outbound flights from Iran.

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## Introduction

The coronavirus disease 2019 (COVID-19) was first reported in Wuhan, Hubei Province, China at the end of 2019, and soon spread to the rest of China and overseas (Bogoch et al., 2020). At the time of writing, 78 630 cases had been reported in China and 3664 cases had been confirmed in 46 other countries (World Health Organization, 2020). Iran has recently become an epicenter in the Middle East region and has seen the largest cumulative number of deaths outside China (Wikipedia, 2020). As of March 1, 2020, Iran had confirmed 987 COVID-19 cases, including 54 associated deaths (Wikipedia, 2020). At least six neighboring countries (Bahrain, Iraq, Kuwait, Oman, Afghanistan, and Pakistan) had reported imported COVID-19 cases from Iran. Given the serious concerns over the under-ascertainment of COVID-19 cases in Iran (ABC News, 2020), the United Arab Emirates (UAE) along with other Gulf Cooperation Council countries suspended inbound and

outbound flights from Iran on February 25, 2020 (Khaleej Times, 2020).

In this study, air travel data and the numbers of cases from Iran imported into other Middle Eastern countries were used to estimate the number of COVID-19 cases in Iran. The calculated estimates were then compared to the number of reported cases in Iran to determine the extent of under-ascertainment.

## Materials and methods

## Data

We obtained data on the transport capability of international airlines from 30 major airports in Iran covering the period February 1 to February 24, 2020 (WorldData, 2020), from the VariFlight platform (<https://data.variflight.com/>). The numbers of exported cases from Iran to other countries in the Middle East were collected (World Health Organization, 2020). The population size of Iran was obtained from the World Bank (<https://data.worldbank.org/>), and was 81 800 269 in 2018. Table 1 shows the daily passenger numbers from Iran and the total reported cases in Middle Eastern countries used in our calculations.

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**Table 1**

Daily passenger numbers and the total numbers of reported cases in the Middle Eastern countries used in the estimation as of February 25, 2020.

Country	Daily passengers from Iran	Reported cases from Iran
United Arab Emirates	1833	2
Lebanon	140	1
Oman	500	2

**Table 2**

Estimated case numbers based on the baseline assumptions and alternative scenarios.

	Effective catchment population	Detection window (day)	Total cases (95% CI)
Baseline	81 800 269	10	16 533 (5925–35 538)
Smaller catchment	60 000 000	10	12 125 (4345–12 145)
Shorter detection window	81 800 269	8	20 667 (7408–44 424)
90% load factor	81 800 269	10	18 368 (6583–39 482)
70% load factor	81 800 269	10	23 627 (8472–50 780)

CI, confidence interval.

## Methods

In accordance with the study by Imai et al. (Imai et al., 2020), it was assumed that the number of cases ( $n$ ) exported from Iran followed a binomial distribution with size  $N$  and probability  $p$ . Here,  $N$  represents the total number of cases infected in Iran, and  $p$  is the probability that one case is detected outside the country. We approximated  $p$  as the ratio of daily outbound passengers from Iran ( $D$ ) over the total size of the population ( $M$ ) that those airports serve and multiplying it by the mean duration ( $t$ ) from exposure to detection; thus,  $p = D \cdot t / M$ . We set  $t$  at 10 days, based on the study by Imai et al. (Imai et al., 2020). It was assumed that the catchment population was the total population of Iran. The maximum likelihood estimate of the total number of COVID-19 cases in Iran ( $\lambda$ ) was calculated by fitting the model to the number of confirmed cases with a binomial-distributed likelihood framework. As shown in Equation (1), the  $l(\cdot)$  represents the total log-likelihood and  $k$  is the total number of countries we selected. The 95% confidence intervals (CI) were calculated using the profile likelihood estimation approach determined by a Chi-square quantile.

$$l(\lambda) = \log \mathcal{L}(\lambda) = \sum_{i=1}^k \log f(n_i, p_i; \lambda) \quad (1)$$

To explore alternative scenarios, a smaller catchment population (60 000 000) and a shorter detection window (8 days) were also considered. We considered a baseline scenario with a 100% attendance rate for each aircraft. In addition, we tested the situations of 90% and 70% flight attendance rates and keeping the other conditions same as the baseline scenario.

## Results and discussion

The total number of cases in Iran was estimated to be 16 533 (95% CI 5925–35 538) by February 25, 2020. Table 2 summarizes the sensitivity analysis of varying the baseline assumptions and the alternative scenarios for the catchment population, detection window, and attendance rates.

As suggested by Zhao et al. (Zhao et al., 2020), underreporting likely occurred during the early stage of the COVID-19 outbreak, due to the shortage of diagnostic kits and inadequate screening of suspected cases (Imai et al., 2020). A recent study by Tuite et al. (Tuite et al., 2020) estimated a total of 18 300 (95% CI 3770–53 470) cases in Iran by February 25, 2020. Our estimates are consistent

with those of Tuite et al. (Tuite et al., 2020), although we used a slightly different approach and a flight data source. We now have two studies with almost identical results.

In conclusion, Iran's ascertainment rate could have been at a level of 0.6% on February 25, 2020. The health security capabilities of many countries in the Middle East are below the world average (GHS Index, 2019), which means that if the epidemic in Iran continues to spread to neighboring countries, the fragile public health systems of Middle Eastern countries are likely to experience difficulty coping with the outbreak.

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## Ethical approval and consent to participate

Not applicable.

## Availability of data and materials

All data and materials used in this work are publicly available.

## Consent for publication

Not applicable.

## Conflict of interest

DH was supported by an Alibaba (China)–Hong Kong Polytechnic University Collaborative Research Project. All other authors declared no competing interests.

## Disclaimer

The funding agencies had no role in the design and conduct of the study, the collection, management, analysis, and interpretation of the data, the preparation, review, and approval of the manuscript, or in the decision to submit the manuscript for publication.

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