Journal of Travel Medicine

International Society of Travel Medicine
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Journal of Travel Medicine, 2022, 1–3
https://doi.org/10.1093/jtm/taac073
Research Letter

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International risk of SARS-CoV-2 Omicron variant importations originating in South Africa

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Submitted 15 March 2022; Revised 9 May 2022; Editorial Decision 10 May 2022; Accepted 10 May 2022

Key words: Omicron, SARS-CoV-2 variant, spreading, importations

South Africa (SA) first detected the B.1.1.529 SARS-CoV-2 variant from a specimen collected on 9 November 2021 and reported the variant to the World Health Organization (WHO) on 24 November 2021.[1] Two days later, the WHO named the variant Omicron and classified it as a variant of concern (VOC) because of increasing detections in SA and large number of mutations in the immunogenic regions of the spike protein.[1] In addition to increasing cases in SA, the new variant may have been prevalent in other locations in southern Africa. By 30 November 2021, over 11 countries had reported detections of the Omicron variant, with the first reports of international importations coming from Hong Kong, Israel, Japan and France.[2] Three days later, it was reported in 29 additional countries.[2] As of 2 December 2021, >50 countries had enacted border controls to slow the global spread of Omicron.[3] For example, Japan and Israel closed their borders to all foreign travellers.[4] The Omicron variant might have been spreading cryptically in these and other countries before the WHO declaration, undetected because of the limited viral sequencing capacity.

Since SA has strong travel links with the rest of the world and was known to have early cases of the Omicron variant, we analysed population mobility data from SA to 14 non-African countries with direct flights in the study period, available through Facebook Data for Good and OpenSky (Table S1), as well as Omicron case report data from SA.[2] We estimated the probability that the Omicron variant was introduced into each country via travellers from SA and the extent of local transmission prior to 28 November 2021 (detailed in Appendix). The United Arab Emirates has the highest expected importation risk between 1 and 28 November 2021, with a date of introduction of 17 November exceeding a 50% chance. By the time Omicron was classified as a VOC (26 November), we estimated that 8 of the 14 non-African regions had over a 50% chance of having received at least one travel-based importation from SA (Figure 1). The remaining two countries—Singapore and Switzerland—exceeded this risk threshold on 27 and 28 November, respectively. By 29 November, 9 of the 10 study regions had confirmed Omicron cases, in contrast with 46% of the total 54 countries, in the GISAID dataset.[2] If Omicron was also prevalent in other countries in southern Africa, the above estimates would be underestimates of the probability of importation in other parts of the world.

Regions that receive a substantial number of travellers from SA were likely to harbour cases of the Omicron variant by late November 2021. Although the UK has lower estimated importation risks than many of the other regions considered, it has reported the largest number of Omicron cases outside Africa, as of 29 November.[2] This reflects the UK's strong genomic surveillance programme, which has contributed nearly 25% of all SARS-CoV-2 sequences globally[5] and suggests that Omicron may be spreading undetected in countries with similar or higher importation risks but perhaps less sequencing capacity.

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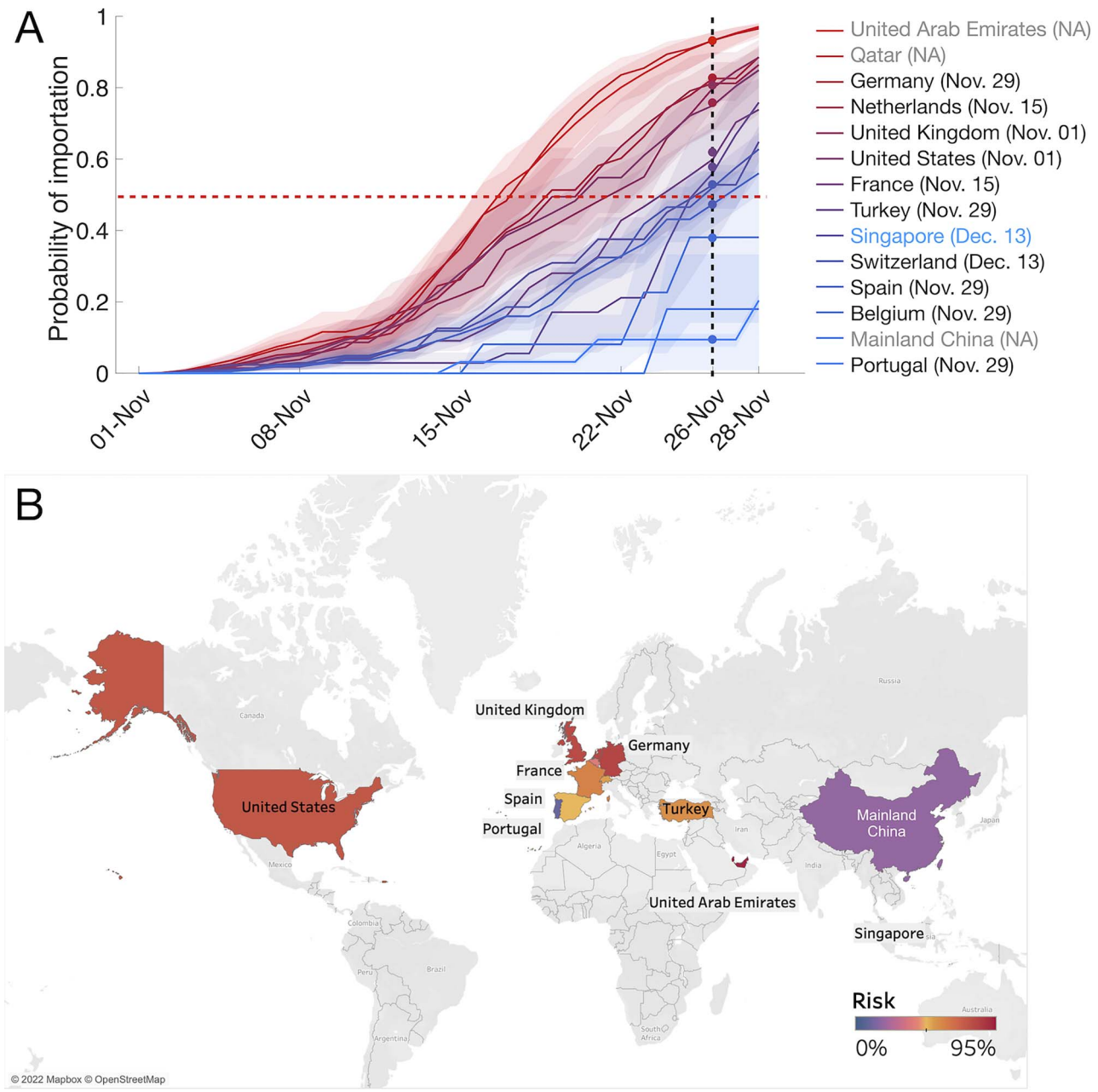

Figure 1. Estimated risks of SARS-CoV-2 Omicron variant introductions from SA to 14 non-African regions on or before 28 November 2021; (A) the probability that at least one person infected with the Omicron variant arrived in a given country from SA by the date indicated on the *x*-axis based on Facebook mobility and OpenSky data; the black dashed vertical line indicates 26 November 2021 when the WHO classified Omicron as a VOC[1]; the red dashed horizontal line indicates an importation probability of 50%; line colours correspond to the relative risk of importations as of 26 November, with red and blue indicating high and low probability, respectively; regions that confirmed Omicron cases or not by 29 November 2021 are listed in black and blue; regions without data are in grey; dates in parentheses as the timing of first omicron reported in GISAID[2]; (B) mean probability of at least one Omicron variant importation from SA by 28 November 2021 in 1000 stochastic simulations; regions in grey were not analysed because mobility data were not available

Our estimates rest on several simplifying assumptions. We assumed that all introductions during this early period occurred via pre-symptomatic and asymptomatic travellers from SA and ignored possible importations from other countries or by symptomatic cases. If the sequences we analysed were disproportionately sampled from regions of SA in which the Omicron variant first emerged, then we may overestimate the relative frequency of Omicron across all of SA. In a retrospective comparison of our projections to subsequent submissions of Omicron variant sequences to GISAID,[2] we find that the order of arrival in these countries roughly matches our estimated risks (Figure 1A, legend). In fact, USA and UK had already reported at least

one Omicron infection by 1 November, suggesting that our projection period starting on 1 November may have led to the underestimation of early importation risks.

We estimate exportation rates from SA using Facebook mobility data without correcting for possible geographic and demographic biases in the Facebook user base. Given that young adults are overrepresented (with 25–34 year olds comprising 32.2% of Facebook users but only 18% of the SA population) and that young adults tend to travel at higher rates than other age groups,[6] we may overestimate travel rates from SA. Similarly, we do not consider correlations between travel behaviour and COVID-19 exposure risks. If age groups with higher travel rates also have higher infection risks, then we may underestimate risks of exportation.

We also note that Facebook mobility data are only available for a small subset of the routes analysed. To fill missing values, we obtained international flight data and used Facebook data from October 2021 to estimate the fraction of seats typically occupied on flights from SA. This strong assumption may lead to underestimation of travel volume to more popular destinations. Our estimates can be updated as we gain further insight into behaviour drivers of risk and epidemiological characteristics of the Omicron variant. Thus, we may underestimate the risks. Should future studies reveal significant epidemiological differences between the Omicron variant and the wildtype, then these estimates can be readily updated.

Supplementary Data

Supplementary data are available at *JTM* online.

Funding

Y.B., Z.D., M.X., P.W., E.H.Y.L., B.J.C. have received research funding from AIR@InnoHK Programme from The Innovation and Technology Commission of the Government of the Hong Kong Special Administrative Region. L.A.M. has received research funding from the US National Institutes of Health (Grant No. R01 AI151176), and The Centers for Disease Control and Prevention COVID Supplement (Grant No. U01IP001136). Z.D. has received research funding from The National Natural Science Foundation of China (Grant No. 72104208) and Health and Medical Research Fund, Food and Health Bureau, Government of the Hong Kong Special Administrative Region (Grant No. 21200632).

Conflict of interests

B.J.C. consults for AstraZeneca, GSK, Moderna, Roche, Sanofi Pasteur, and Pfizer. The remaining authors declare no competing interests.

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