



RESEARCH

INFORMATION

Deriving and validating a risk prediction model for long COVID-19



AIMS

Long COVID is a debilitating condition which can occur after COVID-19 infection. To understand the impact of long COVID and to inform future health care and policy planning we used electronic health records from the entire adult population of Scotland to:

1. Identify the number of cases of long COVID in Scotland.
2. Develop a prediction model for long COVID to identify risk factors for long COVID and assess the risk of long COVID occurring after COVID-19.



KEY FINDINGS

Part 1:

- We identified 1.8% (90,712) of the adult population of Scotland as having long COVID. Of all adults with a positive COVID test, 6.2% (68,486) had developed long COVID.
- Clinical codes for long COVID were rarely recorded in health records (n=1,092, 0.02%). More cases were identified using free text in primary care records (n=8,368, 0.2%), sick notes (n=14,4769, 0.3%), and the newly developed definition for long COVID what we termed a “novel operational definition” (n=64,193, 1.4%).

Part 2:

- The prediction model identified female sex, increasing age (up to 52 years), increasing Body Mass Index (BMI), deprivation; severe COVID-19 infection and several clinical comorbidities and prescriptions as significant predictors of long COVID.
- Being vaccinated, infected by the Omicron variant, or receiving an injectable blood thinning medicine before COVID-19 infection were associated with reduced long COVID risk.

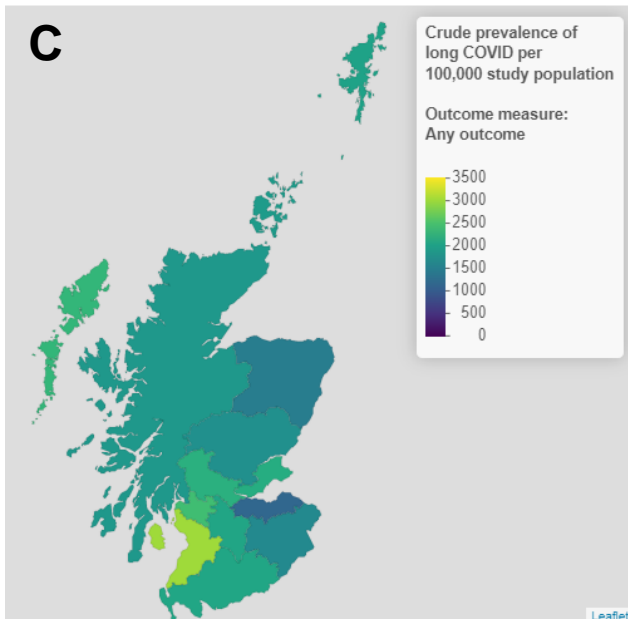
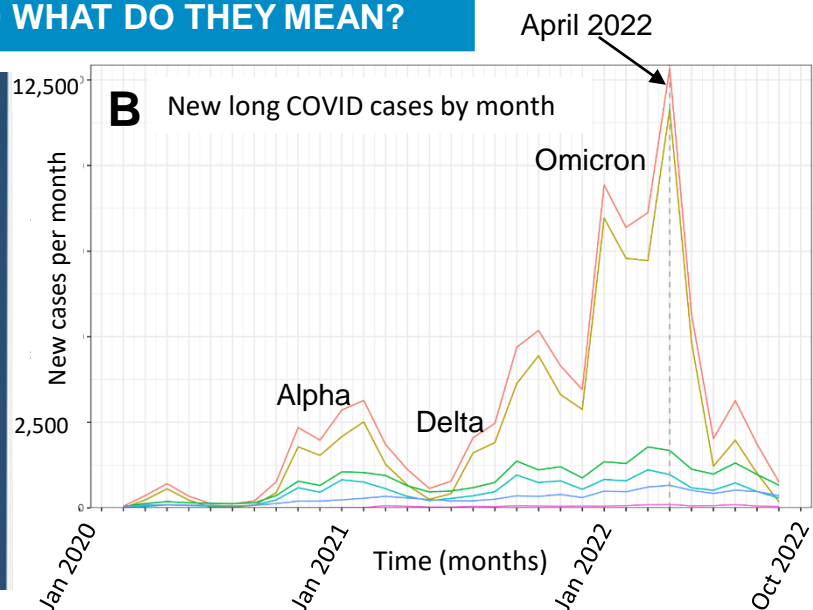
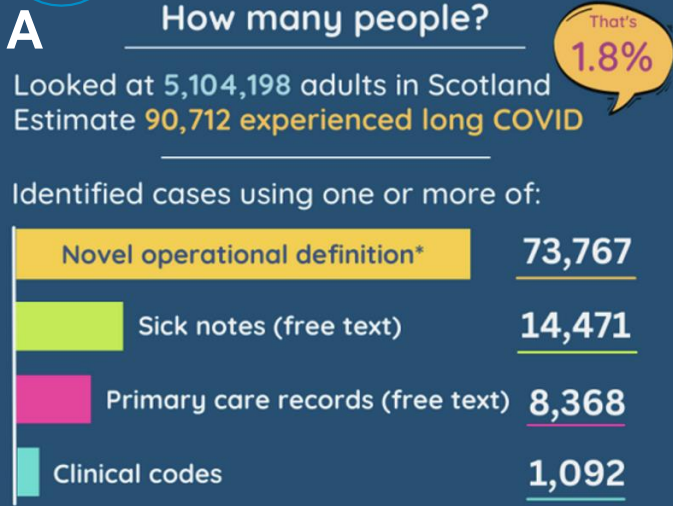


WHAT DID THE STUDY INVOLVE?

- We used health care data from all adults in Scotland. We linked datasets capturing different information including GP and hospital visits, lab tests, COVID variant and prescribing.
- Four ways of identifying long COVID in health records were used: i) clinical codes for long COVID ii) long COVID in free text iii) long COVID sick notes iv) our 'operational definition'.
- Using the four measures allowed us to identify how many people in Scotland had long COVID, and when and where the cases occurred.
- We made a prediction model to identify risk factors for long COVID. The model can calculate the probability that someone will develop long COVID after COVID-19 infection.
- Patient and Public Involvement (PPI) members contributed to grant application, study design, recommending predictors for the prediction model, interpreting of results, feedback on all outputs, media interviews, linking to patient groups and attending steering group meetings.



WHAT WERE THE RESULTS AND WHAT DO THEY MEAN?



Part 1: Long COVID cases in Scotland

- We found 1.8% of adults had experienced long COVID (A). For comparison, this is a similar number to those experiencing strokes which demonstrates the scale of the health burden across Scotland.
- Most long COVID cases were found using the novel operational definition. Long COVID clinical codes were rarely used. This helped us plan for Part 2 of the project, developing a long COVID prediction model.
- The highest number of long COVID cases was recorded in April 2022 (B).
- We provided figures for the Scottish health boards. Within Scotland, the highest regional prevalence of long COVID was in Ayrshire and Arran (C)

These images were created by the Usher Institute, The University of Edinburgh

Part 2: Prediction model

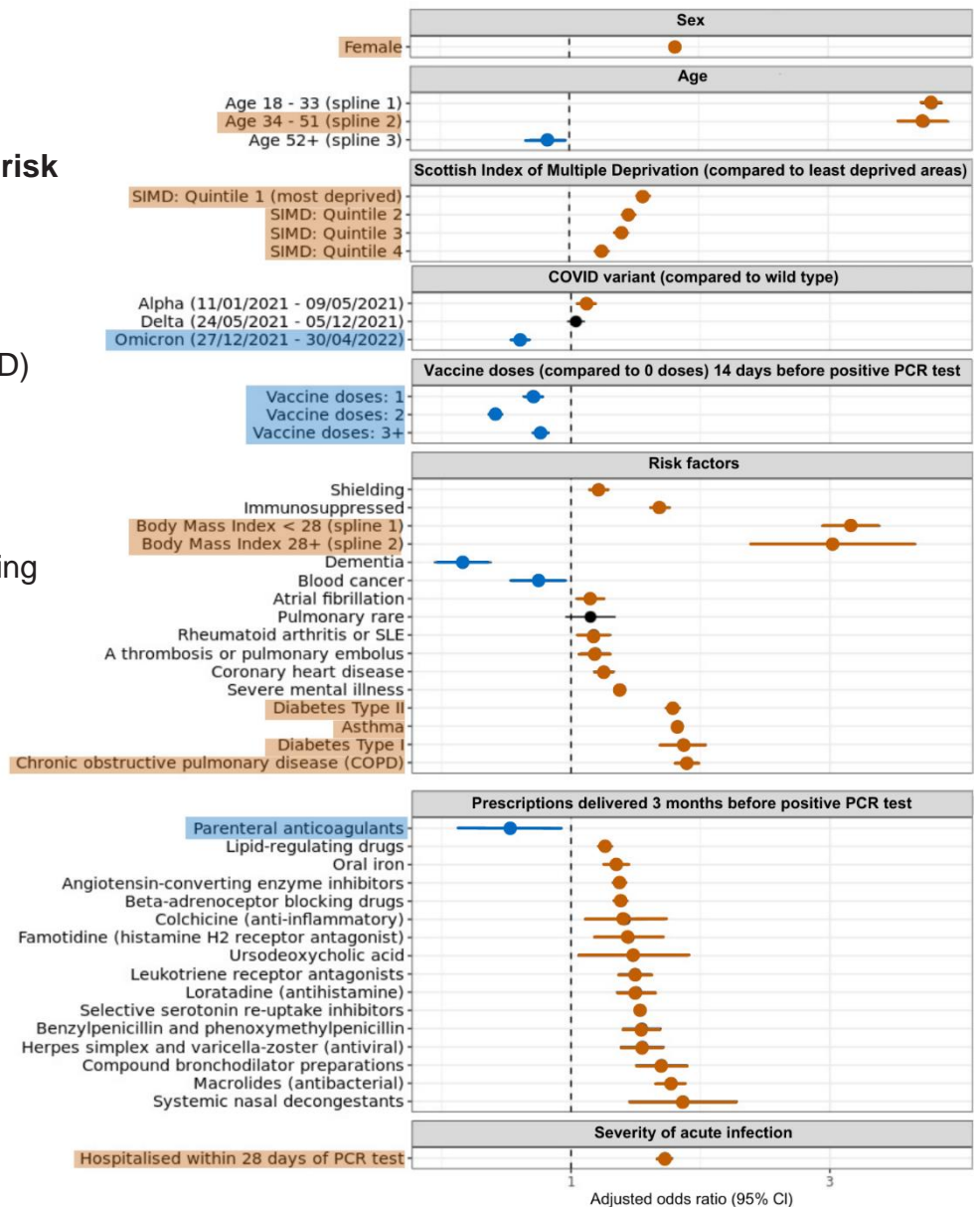
We made a prediction model to calculate the probability of long COVID occurring after COVID-19 infection. The model performed well in the dataset we used. The risk factors we identified for long COVID are detailed below.

Dots to the **right** of the line (**orange**) indicate an **increased risk** of long COVID, including:

- Female sex
- Increasing age (up to 52 years)
- Deprivation (indicated as SIMD)
- Increasing BMI (e.g. being overweight or obese)
- Asthma or COPD
- Diabetes (Type 1 or 2)
- Having severe COVID-19 (being hospitalised)

Dots to the **left** of the line (**blue**) indicate **reduced risk** of long COVID, including:

- Being vaccinated
- Infected by the Omicron variant
- Receiving an injectable blood thinning medicine before COVID-19 infection.



WHAT IMPACT COULD THE FINDINGS HAVE?

- Our data informed Scottish Government and Public Health Scotland on the prevalence of long COVID and provided evidence for the Scottish Parliament long COVID inquiry.
- In addition to the health burden posed by long COVID, our data has been used (and will continue to be used) by Public Health Scotland to inform long COVID health policies.
- The prediction model can be used to better understand the risk of an individual developing long COVID, which can guide personal choices relating to non-pharmaceutical interventions (e.g., wearing a mask) and vaccination.



HOW WILL THE OUTCOMES BE DISSEMINATED?

- Our findings on long COVID in Scotland were broadcast as headline news on the third anniversary of lockdown by the BBC (TV, radio, website), ITV and national newspapers. Our statistics were used to highlight the need for more support for individuals with long COVID.
- To accompany the media release, we produced plain English summaries and infographics which were shared via social media and via long COVID Scotland.
- We have presented results to academic and non-academic audiences at: conferences, and workshops, clinical webinars and two sessions hosted by the Scottish Parliament's COVID-19 Recovery Committee. We will speak to local science groups in 2024.
- We were awarded the Royal Statistical Society Florence Nightingale Award for Excellence in Healthcare Data Analytics who were impressed with the engagement of patients, clinicians and managers and felt this was the type of work "*all analysts should be aiming for*".
- PPI members will promote findings with those who have lived experience of long COVID
- Our protocol has been published and two other manuscripts are under review.



CONCLUSION

Using health data from virtually the entire population of Scotland, we found 1.8% of adults had experienced long COVID.

The prediction model identified that female sex, increasing age (up to 52 years), increasing BMI, deprivation; severe COVID-19 infection, several co-morbidities and prescriptions increased the risk of long COVID. In contrast, being vaccinated, infected by the Omicron variant, receiving an injectable blood thinning medicine before COVID-19 infection were associated with reduced long COVID risk.

The prediction model performed well in the dataset we used. We plan to do further checks on the predictions made by the model by testing it in another dataset.



RESEARCH TEAM & CONTACT

Dr Karen Jeffrey & Dr Luke Daines



The University of Edinburgh
Usher Institute
Old Medical School, Teviot Place
Edinburgh, EH8 9AG



karen.jeffrey@ed.ac.uk
luke.daines@ed.ac.uk



Long COVID website

Additional Information

This project was completed on 31st August 2023 and received £189,658 from the CSO.