QCOVID Risk Prediction Tool

Final Report to NIHR Policy Research Programme

May 2024

RESEARCH TEAM

The research team was led by the University of Oxford and involved researchers from the Universities of Cambridge, Edinburgh, Swansea, Leicester, Nottingham and Liverpool with the London School of Hygiene & Tropical Medicine, Queen's University Belfast, Queen Mary University of London, University College London, the Department of Health and Social Care, NHS Digital and NHS England.

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KEYWORDS

COVID-19; risk stratification; risk prediction; validation; QResearch; EAVESII, SAIL.

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1 Lay summary

When COVID-19 struck in 2020, the NHS was faced with a huge challenge – we had a new virus and no information about how the virus would behave or who was most vulnerable to its effects. We did not know how best to identify and prioritise patients for shielding and also vaccinations as these became available.

Thanks to the National Institute for Health and Care Research (NIHR), a team of researchers was commissioned in May 2020 to develop a model called QCOVID® that sought to predict the risk of people becoming seriously ill or dying from COVID-19. The model was used to inform UK health policy, and its use by NHS Digital helped prioritise 820,000 people for COVID-19 vaccinations. It was also used by doctors and nurses with individual patients to give more accurate information on a person's susceptibility to serious outcomes from COVID-19 to help patients make better decisions about their health. The QCOVID model was tested in different settings across the UK and found to be accurate and effective.

As the pandemic progressed, and further vaccines were introduced, new variants of the virus emerged and better data became available, the model was then updated accordingly.

This is the first time worldwide that such a prediction model has been used across a country to identify patients at high risk of COVID-19 to target interventions and so there was extensive engagement with patient and professional representatives throughout the project. As a result of this, we have not only a useful tool for clinical assessment for risk of COVID-19, but the NHS now has produced a set new standard on how to develop and use such tools to find patients at highest risk of serious diseases quickly. This means we can now maximise the potential benefits of future preventive approaches and treatments more widely by targeting them to those at greatest risk who are most likely to benefit.

2 Executive Summary

2.1 Background

At the outbreak of the COVID-19 pandemic, the NHS urgently needed a way to identify people whose health was most at risk if they caught coronavirus. The Chief Medical Officer (CMO) for England, acting on behalf of the devolved nations CMOs, commissioned a team of leading researchers and clinicians from around the UK to create a way of predicting patient groups most at risk of serious outcomes from COVID-19 infection.

2.2 Aims

To derive and validate a risk prediction algorithm to estimate hospitalisation and mortality outcomes from COVID-19 in adults.

2.3 Design

Population-based cohort study using the QResearch database, comprising 1205 general practices in England with linkage to COVID-19 test results, Hospital Episode Statistics and death registry data for model development. Similar databases in England, Wales and Scotland for external validation.

2.4 Settings

Adults aged 18-100 years, with over 6 million in the derivation dataset, and over 2 million in the validation data set. The first validation cohort period was 24th January to 30th April 2020. The second temporal validation cohort covered the period 01 May 2020 to 30th June 2020. Subsequent cohorts were assembled in 2021,2022 and 2023 as the pandemic progressed and updates to the models and external validation were required.

2.5 Main outcome measures

The primary outcome was time to COVID-19 death, defined as confirmed or suspected COVID-19 death as per death certification or death occurring in an individual with confirmed SARS-CoV-2 infection. The secondary outcome was time to hospital admission with confirmed SARS-CoV-2 infection. Performance, including measures of discrimination and calibration, was evaluated in each validation time period.

2.6 Results

The QCOVID risk algorithms included age, ethnicity, deprivation, body mass index and a range of comorbidities. The algorithms had good calibration and discrimination in the first validation cohort. For example, for COVID-19 deaths in men it explained 73.1% (95% CI: 71.9 to 74.3) of the variation in time to death (R^2); the D statistic was 3.37 (95% CI: 3.27 to 3.47); Harrell's C was 0.928 (95% CI: 0.919 to 0.938). Similar results were obtained for women, both outcomes and in subsequent time periods and external datasets. In the top 5% of patients with the highest predicted risks of death, the sensitivity for identifying deaths within 97 days was over 75%. People in the top 20% of predicted risk of death accounted for 94% of all COVID-19 deaths and the top 50% of people accounted for 99% of deaths.

Subsequent versions of the algorithms produced in 2021-2023 included prior COVID-19 infection and number of COVID-19 vaccination doses and had excellent performance as shown in multiple external datasets in the UK.

2.7 Conclusion

The QCOVID algorithms population-based risk algorithm performed well showing very high levels of discrimination for COVID-19 deaths and hospital admissions. The absolute risks presented changed over time in line with prevailing COVID-19 infection rate and the extent of social distancing measures in place and the use of COVID-19 vaccination. The model was updated and recalibrated several times for different time periods and has the potential to be dynamically updated in the future.

QCOVID has been used to support public health policy, from enabling shared decision making between clinicians and patients to mitigate health and workplace risks, to targeted recruitment for clinical trials, and prioritisation of vaccination and novel COVID-19 therapeutics.

3 Introduction to this report

This report summarises a large amount of research which was funded by NIHR over the first three years of the COVID-19 pandemic (2020-2023). The under-pinning research produced by this grant has been published as a series of 12 peer reviewed medical research papers undertaken by the academic team. The detailed methods, results and discussion for each research paper are available via the embedded links and enclosed folder,and are not duplicated here.

The description of the research below has been adapted from the NIHR published case impact study and is intended to be a widely accessible summary.

We summarise the impacts that our work had on emerging national policy during the pandemic. Again, there are further embedded links to external policy related documents.

This project was unusual since the research was being translated into policy and then implemented as clinical tools within the NHS, much more quickly than has ever been the case before. This was due to the urgent nature of the COVID-19 pandemic, particularly in the first two waves when intensive care beds in the NHS were full and there was huge pressure on front line staff. Much of the work, that hitherto would have been done in sequence, had to be conducted in parallel and at pace. This was only possible because of the track record, skills and high levels of commitment of large number of individuals and organisations who collaborated to deliver this work for the NHS. Our collective work has been recognised in a series of awards which are also listed in this report.

None of our work would have been possible without the high quality routinely collected anonymised data that we have in the NHS and which were made available quickly and efficiently for research. There are many people, behind the scenes, who facilitated this by enabling critical IT infrastructure, administering finance and data sharing agreements across multiple organisations who deserve our thanks.

We summarise our approach to patient engagement and involvement. Our various representatives participated in this from the outset and throughout the last three to four years and without them our work would have been less valuable, useful and accessible. Our patient representatives helped us by refining our research questions, advising on how to communicate our plans, interpreting our findings, challenging us on issues relating to data quality and equity and providing a framework for considering how to approach this sort of research in future via the Citizen's Jury report. We thank them most of all.

4 The Research

4.1 Identifying people at high risk from COVID-19

At the outbreak of the COVID-19 pandemic, the NHS urgently needed a way to identify people whose health was most at risk if they caught coronavirus. The Chief Medical Officer (CMO) for England, acting on behalf of the devolved nations CMOs, commissioned a team of leading researchers and clinicians from around the UK to create a way of predicting patient groups most at risk of serious outcomes from COVID-19 infection.

Funded by the NIHR, the research team, comprising experts from 12 institutions across the UK, collaborated to develop a new approach to identifying patients' risks at a population level and at an individual level across diverse populations. Led by Professor Julia Hippisley-Cox, Professor of Clinical Epidemiology and General Practice at the University of Oxford, the team began their project with an analysis of a pre-existing database of more than 8 million people aged 19–100 years. The information included anonymised GP records, hospital records, COVID-19 test results and death registrations corresponding to the first wave of the pandemic (late January to April 2020).

The researchers used these data to identify which combinations of health and personal factors put patients at greater risk of hospital admission or dying from COVID-19 infection, so they considered characteristics such as age, gender, ethnicity and body mass index (BMI). They also looked at the effects of certain treatments and medical conditions, including cardiovascular disease, diabetes, respiratory disease and cancer.

Using the findings from these analyses, the team developed a clinical risk prediction model, QCOVID®. They then tested how well this model predicted hospital admissions or deaths from COVID-19 infection using the health records of a separate set of people.

QCOVID® performed well in predicting patients' outcomes, with those identified by the model to be in the top 5% for predicted risk of COVID-19 death accounting for approximately 76% of actual COVID-19 deaths during the study period, and people in the top 20% accounting for 94% of COVID-19 deaths. The study's results have been published in the British Medical Journal.

Our population-based risk model has broken new ground by identifying the patients at highest risk of COVID-related death and hospital admission, so that the NHS can target resources to the most vulnerable and those most likely to benefit. Moreover, this work demonstrated the value of having a cross-partnership team of multiple specialities in delivering innovative research and improvements for the healthcare system.

The QCOVID model has been independently validated by the Office for National Statistics (ONS), confirming that the model performs in the 'excellent' range and can accurately identify patients at highest risk from COVID-19. ONS validation is considered the gold standard of evidence and assurance, and QCOVID® is thought to be the only COVID-19 risk prediction

model in the world to meet this standard. The validation study's results were published in The Lancet Digital Health.

The QCOVID® model was also validated for use in Scotland using Scottish population data (EAVE II, results published in Thorax), and in Wales using the SAIL Databank (published in the International Journal of Population Data Science). Professor Ronan Lyons, Professor of Public Health at Swansea University and contributor to the QCOVID® research, commented that: "The validation of QCOVID® in Wales has helped enormously in informing policy responses to those at greatest risk."

4.2 Extending COVID-19 risk assessment to all adults

At the beginning of 2021, people on the existing Shielded Patient List (SPL) - which comprises people identified as being at high risk of dying from COVID-19 based on having a single underlying disease - were prioritised for COVID-19 vaccination, in line with guidance from the Joint Committee on Vaccination and Immunisation.

Less than a year after our NIHR-funded research began, the QCOVID risk prediction model was used by NHS Digital to develop the COVID-19 Population Risk Assessment. In this new assessment, NHS Digital applied the QCOVID® model to NHS patient data in England, to identify people not already included on the SPL in England who might be at high risk of dying from COVID-19 infection.

Using the same assessment of combined factors, including age, BMI, specific health conditions and treatments, the COVID-19 Population Risk Assessment identified a further 1.7 million high-risk people who were added to the SPL and advised to shield. This included 820,000 adults aged 19–69 years who were also prioritised for vaccination (as the over-70s in the identified high-risk group had already been prioritised). Automatically adding high-risk patients to the SPL ensured that as many patients were protected as quickly as possible.

For the first time, the researchers were able to go even further in protecting the most vulnerable in our communities. The model's data-driven approach to medical risk assessment helped the NHS identify additional individuals who may be at high risk from COVID-19 due to a combination of personal and health factors.

Dame Jenny Harries, former Deputy Chief Medical Officer for England and Chief Executive of the Health Security Agency said "*NHS Digital also used QCOVID® to produce the COVID-19 Clinical Risk Assessment Tool, to help clinicians review individual patients' risk level and add or remove them from the SPL as required. The adoption of this risk assessment model by the NHS will play an important role in supporting clinicians and patients with conversations about COVID-19 and enable decisions to be made with a greater understanding of personal risk*".

Professor Andrew Goddard, President of the Royal College of Physicians said "*Although QCOVID® has been specifically designed to inform UK health policy and interventions to manage COVID-19 related risks, the research team have suggested that it could be implemented by other countries following their own local validation*".

The QCOVID® research team won the Royal College of General Practitioner's Overall COVID research paper of the year award (2020) for its academic publication in the BMJ. The research team and wider group of collaborators who developed the COVID-19 Population Risk Assessment - which included representatives from the Department of Health and Social Care, NHS Digital and NHS England - also collectively won awards, including the John Perry Prize for outstanding use of IT, Health Service Journal Award Best Use of Technology Award for QCOVID risk stratification (highly commended) and the Florence Nightingale Award for Excellence in Healthcare Data Analytics awarded jointly by the Health Foundation and the Royal Statistical Society (RSS). The RSS said "The work powerfully demonstrates the value that high quality analytics can have at a nationwide scale. The level of collaboration, careful navigation of obstacles and focus on addressing health inequalities were all considered outstanding".

4.3 Identifying COVID-19 risk after vaccination

As the COVID-19 vaccination programme was developed and rolled out to the adult UK population in 2021, there were concerns that the vaccine may not provide effective protection for some more vulnerable patient groups. This would leave them at increased risk from COVID-19 infection and subsequent hospital admission or death.

To help identify and urgently protect those most at risk, the QCOVID® team were once again commissioned by the CMO for England on behalf of the UK government to develop new risk models to predict people's risks of hospital admission or dying from COVID-19 after receiving either one or two doses of vaccine. The team analysed data from a sample of over 6.9 million vaccinated adults, of whom 5.2 million had received both vaccine doses, which was representative of the UK population.

The research, published in the BMJ, recorded 1,929 COVID-19-related hospital admissions and 2,031 COVID-19 deaths within the sample, of which 71 admissions and 81 deaths occurred at least 14 days after the second vaccine dose.

The team's findings indicated that people receiving treatment for cancer or autoimmune disorders, care home residents and those with HIV/AIDS or neurological disorders were among those who remained at higher risk of hospitalisation or death from COVID-19 after one or two vaccine doses. The study did not distinguish between the type of vaccine received.

This enormous national study of over 5 million people vaccinated with one or two doses across the UK has found that a small minority of people remained at increased risk of COVID-19 hospitalisation and death. Our model (QCOVID3) helped to identify those who remained most at risk post-vaccination, We also developed risk prediction models in people who had not been vaccinated (QCOVID2).

Further validation of QCOVID2 and QCOVID3 has been undertaken in Scotland and Wales following a common protocol. This is one of the first times that a risk prediction tool has been systematically updated and externally validated in the devolved administrations.

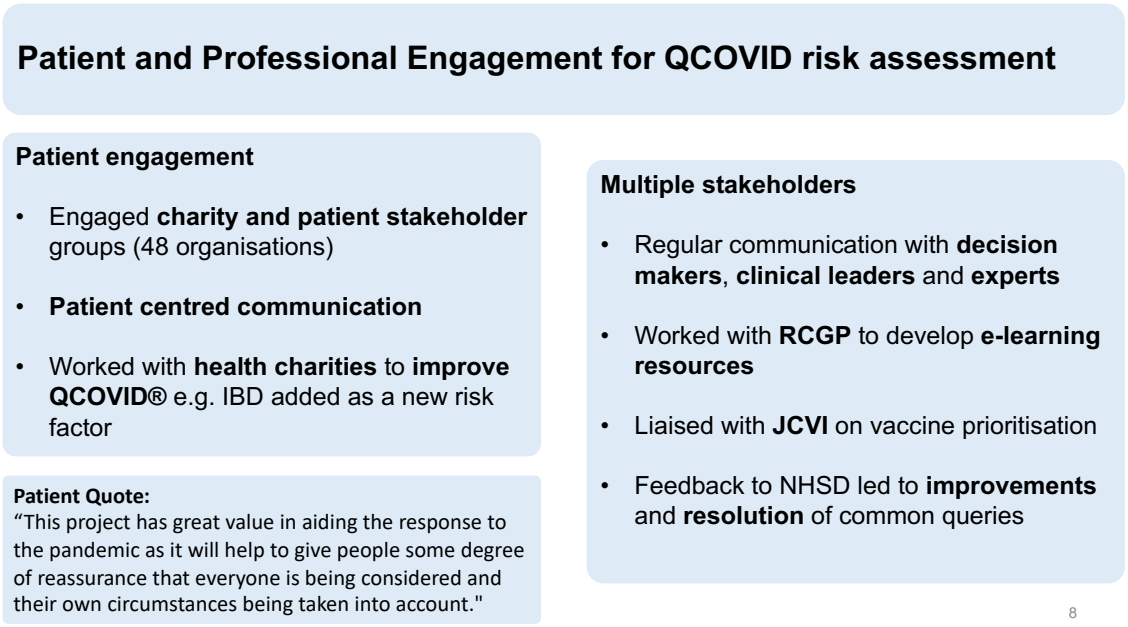
Professor Aziz Sheikh, Professor of Primary Care Research and Development at the University of Edinburgh and a member of the QCOVID® research team, said "*NHS Digital subsequently updated the Clinical Risk Assessment Tool to include this new evidence. Together the QCOVID® model developed by NIHR researchers and the risk assessment tools developed by NHS Digital and its collaborators have helped protect the patients most at risk during the COVID-19 pandemic*".

We have also published work on methodological approaches to dynamic updating of risk prediction models which found that a dynamic updating process outperformed a one-time discrete updating process using simulated data. This will be useful in future as further COVID-19 variants arise and new interventions are delivered and may also have applications for other conditions beyond COVID-19.

Make mention of QCOVID4 in Omicron era.

5 Details of patient and public involvement in the research

We worked with many different patient organisations throughout the pandemic as shown in the above Figure provided by DHSC below.



Additionally, we would highlight the following organisations and work:

- Scottish Government Citizen's Jury
- Applied Research Collaborations East Midlands (ARCEM)
- EAVEII Patient Group (see Appendix 1 for report)

5.1 Scottish Government Citizen's Jury

The Scottish Government commissioned a Citizens' Jury exploring public views on QCOVID. The full report is available at this link: The Citizens' Jury on QCOVID: Report on the jury's conclusions and key findings and we have included the summary from the report here as this is the first time a Citizens' Jury has undertaken a review of a risk prediction algorithm.

This Citizens' Jury set out to help understand how the public in Scotland view any ethical issues associated with the Scottish Government's proposed use of QCOVID® or similar risk prediction models. Through an in-depth process of learning and deliberation, the Citizens' Jury provided clear messages on the ethical concerns around deploying a model like QCOVID®. The jury looked in detail at each of the four possible tools associated with QCOVID®, and this report has set out their principles (i.e., what would make use of each tool acceptable) and "red lines" (i.e., what would render use of each tool unacceptable). Rather than restate those principles and "red lines", here we highlight the overall themes that emerged from this public engagement exercise and the implications for future policy in this area.

Findings underscore the importance of transparency around the use of any such tool. *Participants were generally accepting of the reasons for applying a risk prediction model, feeling that they could help minimise some of the most serious outcomes of the pandemic. However, a theme throughout the jury was the need to keep the public informed about how the model was being used and what that meant for individuals who were identified as at risk. This level of transparency was considered important for the Scottish Government to build public trust in the tool.*

Linked to the need for transparency was the importance of communication*. If the Scottish Government was to decide to use QCOVID® or a model like it, participants felt that this should be clearly communicated to the public. Communication of the outcome of the risk prediction was also seen as an important consideration, with care needed in relation to how a high-risk individual is informed of the outcome.*

The need for support for individuals deemed at high risk was one of the strongest themes to emerge. *Participants stressed the potential severity of being told you are at high risk of serious outcomes from Covid-19, and the negative emotional impacts of being asked to isolate or reduce contact with others. In this respect, the timing of this public engagement exercise seemed to have had an impact – having lived through almost two years of Covid-19, participants were able to draw on their own experiences, or that of their family members, of being asked to shield early in the pandemic. If adequate support cannot be provided, then some felt the model should not be used. Any future use of the model should therefore consider what means of support will be available to high-risk individuals and how this will be communicated to those individuals. Support would include three elements:*

- *Emotional – to offer reassurance to people receiving a score which is upsetting to them.*
- *Interpretative - to help people understand their risk score and what it means.*
- *Practical – to help people understand what steps they needed to take to protect themselves and others, and support to help make sure they could access what they needed (e.g. access to food and essential items if they were being asked to shield).*

The Citizens' Jury also highlighted the importance of having data security and privacy systems in place. *Concerns around data security have been covered in previous public engagement exercises on this topic, so it is not surprising that they formed a key part of the deliberations in this Citizens' Jury. Across all the tools that were discussed, the general point raised was that an individual's data should be kept safe and not used for purposes unrelated to managing the health risk of the virus. This was particularly important in the case of the population tool using non-anonymised data. For any future*

use of the tool, it will therefore be important that data security protocols are in place and that these are clearly described to the public.

***Findings suggest that attitudes towards risk prediction models can vary depending on the status of the virus**. In particular, if there is low prevalence of the virus and vaccines are effective, participants felt there would need to be very clear justification from the Scottish Government for a model like QCOVID® to be used. This was particularly the case for tools that carried relatively higher risk, such as the population level use of non-anonymised data (which had higher risks associated with data privacy and need for support for individuals). In the case of a new variant resistant to vaccines, participants felt that a model like QCOVID® could potentially become more important, as the need to manage the impacts of the virus would be more serious and urgent. However, the same principles and conditions around its acceptability would still apply under that scenario.*

***Finally, our findings also highlight the impact that the process of deliberation can have on attitudes towards use of public health data.** Participants' views developed over the course of the Citizens' Jury as they learned more about the tools and deliberated with each other. The wider public, who will not have taken part in deliberation, may receive information about a risk prediction model differently. If the Scottish Government is to use a model like QCOVID®, it will therefore be important that the public engagement messaging draws on, and responds to, the range of ethical considerations highlighted by the Citizens' Jury.*

5.2 Applied Research Collaboration East Midlands (ARCEM)

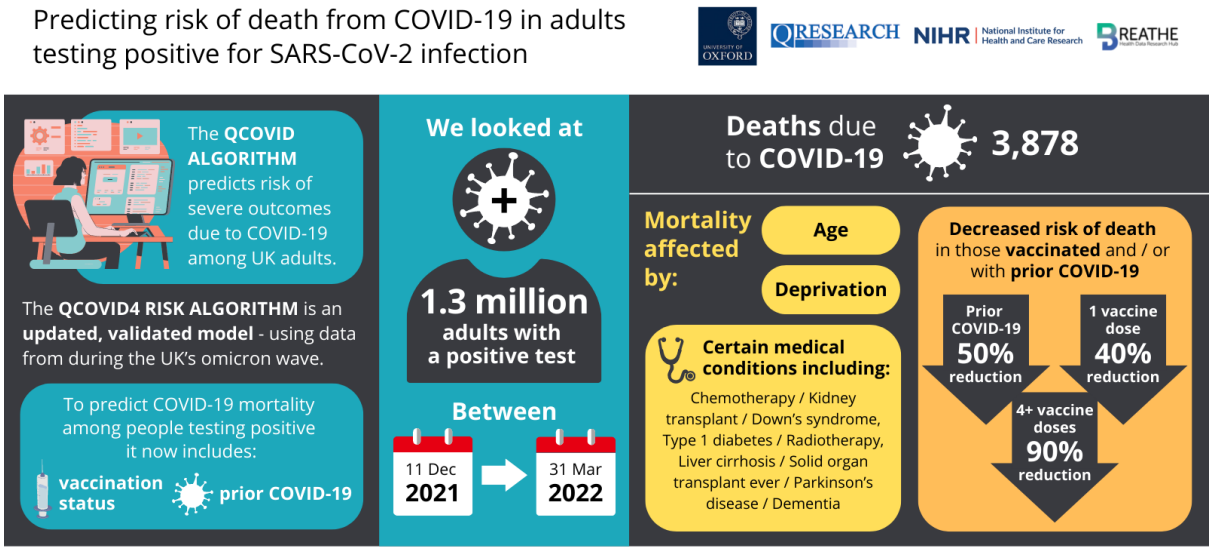
With ARCEM and our immune compromise PPIE group, we together worked through the QCOVID risk tool, using fictional vignettes, which we adapted and altered as a group to explore how and whether this made a difference to risk. We also asked for feedback about how risk was communicated and explained when looking at the QCOVID tool. We spoke with the group when QCOVID2 and QCOVID3 were being piloted, and then went back to the same group when QCOVID4 was under evaluation, to share what changes had happened and ask for further feedback.

The group had questions about who the tool was for, and how it would be used in different organisations or by different people, which resonates with the citizen's jury work. They made suggestions to improve the accessibility of the tool - which included simplifying the language, clarity about intended use and setting, availability in different languages, infographics, audio or video linked versions, and resources and instructions to accompany usage. They gave feedback and advice about framing and structuring all of the questions asked in the risk assessment tool. This included links to information about 'why were are asking' to explain how and why data was being asked and how it could be used. This also included having 'prefer not to say' as the first available option for gender and ethnicity. The immune compromised group raised a concern that giving their postcode, combined with a rare condition, might risk them being identifiable. The groups suggested conversion tables for height, weight, and diabetes control. The groups felt that there was potential for clarification and a risk of confusion in the medical condition questions from their perspective. The categorisation of immune suppressing medications and conditions was an area where clarity was requested. In terms of risk communication, they wanted the numbers but accompanied with an infographic or graphical representation. There was preference expressed for people in a queue, but less support for emojis or happy faces, with concern expressed that this was too emotive or risks

minimalizing risk. The dial received a mixed response, with some liking the clarity, and others finding it frightening.

Ethnicity was an example of a variable considered important but also potentially complex and sensitive. The group raised support for including ethnicity but raised important questions about how the data is collected. They reflected that experiences of being asked about ethnicity can align with fears or experience of discrimination, and that it is crucial this is considered. Collaboration and explanations, with transparency about how data are gathered, what the limitations are, how they are used, and why, can help with this.

The group helped improve the QCOVID4 infographic, including advising on imagery and wording, for example changing the phrase prior covid to one that was more easily understood and clearer.



Conclusion | **The model has excellent performance and could be used for targeting COVID-19 vaccination and therapeutics.**

6 An explanation of how your work addresses equality and diversity issues*

EDI considerations were paramount throughout all aspects of our work including PPIE activities. We worked in partnership with ARCEM to ensure that our PPIE process was fair, representative and respectful of the diverse communities that we are working with. As well as ensuring a diverse representation within the work which includes members from underrepresented groups, we ensured cultural sensitivities were also considered. Materials were developed and available in various formats as well as using inclusive language within communication at all times. With ARCEM, we created environments that were comfortable for participants, allowing them to openly express views and opinions.

We collaborated with ARCEM, striving for inclusive PPIE input. In parallel, we held PPIE meetings with a group of people with experience of living with conditions or medications that impaired their immune systems. They advised on both how the toolkit was experienced or navigated and on how the research was communicated about, for example advising on the

infographic language and design. They helped identify other important considerations, for example contextualising documentation of ethnicity in recognition that this data may have been collected in association with experiences of discrimination or stigma, and that communication about research needs to respect, acknowledge and mitigate against this. They asked that 'I do not wish to reply' be the top options for ethnicity and gender.

Finally by including ethnicity as a variable in our prediction model, we were able to include different weights for different ethnic group according to their level of risk. This meant that the QCOVID tool was able to implement equitable access to vaccines since the tool itself captured different levels of risks by ethnic group.

7 A list of outputs from the project

7.1 Original Research Papers

1. Clift AK, Coupland CAC, Keogh RH, Karla Diaz-Ordaz K, Williamson E, Harrison EM Hayward A, Harry H, Horby P, Mehta N, Benger J, Khunti K, Spiegelhalter D, Sheikh A, Valabhji J, Lyons RA, Robson J, Semple MG, Kee F, Johnson P, Jebb S, Williams T, Hippisley-Cox J. Living risk prediction algorithm (QCOVID) for risk of hospital admission and mortality from coronavirus 19 in adults: national derivation and validation cohort study *BMJ* 2020; 371; doi.org/10.1136/bmj.m3731.

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9. Tanner K, Keogh R, Coupland C, Hippisley-Cox J, Diaz-Ordaz K. Dynamic Updating of Clinical Survival Prediction Models in a Changing Environment. *Diagnostic and Prognostic Research*. 2023; 7:24. https://doi.org/10.1186/s41512-023-00163-z

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7.2 Press releases

- Development and evaluation of a tool for predicting risk of short-term adverse outcomes due to COVID-19 in the general UK population; Press Release
- COVID-19 is 10 times deadlier for people with Down syndrome, raising calls for early vaccination
- Oxford-led technology to help those at high risk from Covid-19
- Model that predicts patient risk from COVID-19 wins Florence Nightingale Award for Excellence in Healthcare Data Analytics
- COVID-19 risk prediction tool wins national award
- QCOVID highly commended for 'best use of technology in Patient Safety' at the 2021 HSJ Patient Safety Awards
- COVID-19: QCOVID tool's new algorithm identifies those most at-risk from coronavirus after vaccination

- New tool identifies groups most at-risk from Covid after vaccination
- Covid travel news: Government to introduce charges for tests, as bookings surge after rules eased
- People with chronic conditions among most at risk from Covid even after jabs
- Researchers identify vaccinated patient groups most at risk of serious Covid
- Older people and men 'more likely to suffer' with Covid even after two jabs
- Men 'more likely' to face severe outcomes following double-vaccination, warns new study
- Calculator reveal which vaccinated Brits are most at risk of dying from Covid
- Researchers unveil algorithm to identify COVID-19 patients at high risk despite vaccination
- People with Down's syndrome and severe kidney disease are most at risk of being admitted to hospital or death after having two Covid vaccines, study finds
- Age, illness and vaccine status still biggest factors as new Covid calculator shows who's most at risk
- Vaccinated groups at highest risk of Covid-19 hospitalisation and death identified using new QCOVID tool
- Hippisley-Cox wins John Perry Prize for pseudonymisation tools made available by QResearch(29 October 2013)
- Covid research partnership wins national computing innovation award
- Our Open Access Publication of the Month - January 2022

8 Policy Approach, Relevance and Outputs

8.1 Policy approach

This research was commissioned by the four UK CMO in May 2020 and due to the urgent nature of the request and the need to be able to implement a robust national risk stratification programme to support the first roll out of the COVID-19 vaccination programme, the academic team worked very closely with DHSC and policy colleagues from the outset. Faced with a novel virus, with unknown risk factors, uncertain natural history and limited data on those who had had been infected in the first waves, the academic challenges were substantial.

Research findings were disseminated in near real time, often immediately as they were produced, with multiple agencies including four CMO's Offices, DHSC, Scottish and Welsh governments, NHS Wales, NHS Scotland, Office of National Statistics, NHS England, NHS Digital, Cabinet Office, UKSHA, NERVTAG, SAGE, JCVI, NICE, MHRA, national COVID-19 advisory groups, RCGP and the other Royal Colleges.

Together with the CMO's office and DHSC, we liaised with over 48 patient groups to communicate findings as the findings emerged and were implemented.

8.2 Policy Group Involvement.

We contributed to the following policy group meetings:

- SAGE Ethnicity Sub-Group:
- SAGE Vaccine Science Co-Ordination Group
- NERVTAG
- NERVTAG Risk Stratification Sub-Group (JHC was chair)
- SAGE 40 Commission- Occupational Risk
- Joint Committee on Vaccines and Immunisations (JCVI)
- Covid-19 Vaccine Benefit Risk Expert Working Group
- DHSCG Risk Stratification Implementation Group
- Welsh Government COVID-19 Technical Advisory Group

8.3 Timeline policy impact

Below is a non-exhaustive indicative timeline to illustrate how the research findings were relevant to and impacted on the various phases of the pandemic.

- Aug 2020 – Paper presented to SAGE highlighting the results from the first version of the QCOVID risk algorithm.

- Dec 2020 - Analyses for SAGE ethnicity group, directly informed policy on mitigations for BAME. The Runnymede Trust, an independent race equality think tank, highlighted this publication as a 'watershed' moment since it was the first time the government acknowledged differential impact of COVID-19 by ethnic group.

- Dec 2020 – Cabinet office briefing by DHSC on the utility of the QCOVID model and plans for national risk stratification following requests from the four UK CMOs that QCOVID be embedded into the NHS as quickly as possible.

- Jan 2021 – JCVI issue guidance on initial vaccine roll out incorporating QCOVID evidence

- Feb 2021 – DHSC issue a press release relating to the planned use of QCOVID to risk stratify 50 million people in England.

- Feb 2021 -Results shared with the Joint Committee on Vaccination who adapted national vaccine policy to prioritise relevant risk groups, particularly patients with Down's syndrome and other learning disabilities. JCVI made its' recommendation to the Secretary of State for Health

- Feb 2021 – The Secretary of State for Health replies to ask the NHS to ensure that everyone on the learning Disability Register is invited for early vaccination.

- Feb 2021 – QCOVID clinical risk assessment tool was made available across primary and secondary care on 16th Feb 2021 and was a key part of the COVID-19 Response RoadMap published in Spring 2021.

- June 2021 - The Secretary of State highlighted the utility of QCOVID for protecting those who were most vulnerable to severe outcomes from COVID-19 in his report entitled Building the best health system in the world.

- Sept 2021 – the value of QCOVID in providing mortality insights was highlighted by the Office of National Statistics.

- Sept 2021 – QCOVID used to stratify patients into a clinical trial.

- Dec 2021 – QCOVID informed the final report on progress to address COVID-19 health inequalities published by the Race Disparity Unit and Equality Hub. Specifically QCOVID addressed Recommendations 5 and 6 to ensure that new evidence related to clinically extremely patients was incorporated into health policy leading to an additional 1.7 million patients identified as high-risk being added to the national Shielded Patient List.

- Dec 2021 - Evidence identifying those at high risk of adverse COVID-19 outcomes, most likely to benefit from novel Monoclonal Antibodies was presented to the National Expert Group leading to a new national policy used by NHS Digital to send priority letters to 1.25 million people.

- Mar 2022 The Office for Statistics Regulation published a case study using QCOVID as an exemplar for Lessons in Commanding Public Confidence in models. In particular, the report stated the following "*QCOVID® provides a great example that models and algorithms can command public confidence when the principles of Trustworthiness, Quality and Value (TQV) are considered and applied. In terms of how we will use these findings going forward, we have updated our algorithm review framework and this example will feed into the wider OSR work on Guidance for Models as it continues to be developed this year*."

- June 2022 – DHSC published a report on algorithm transparency, setting a new standard for the NHS, using QCOVID as the exemplar.

- Nov 2022 – QCOVID was highlighted in the Government Actuary's Department annual report and accounts for 2021-2022

- Dec 2022 – The Technical report on the COVID-19 pandemic in the UK published by DHSC to advise on future pandemics highlighted the importance of the QCOVID tool and its application.

- May 2023 – Further evidence from QCOVID2 and QCOVID3 on who is at highest risk of an adverse COVID-19 outcome was submitted to the DHSC task force. The recommendations in the report continue to support deployment of COVID-19 therapeutics, including in community settings, and form the definition of highest risk in the National Institute for Health and Care Excellence (NICE) multiple technology appraisal.

- June 2023 QCOVID was also a case study in the Policy Paper, Data Saves Lives, reshaping health and social care with data.

Case study: identifying the most at risk of COVID-19

Early on in the COVID-19 pandemic, the Chief Medical Officer commissioned a research consortium to create a model to predict which combination of factors could increase risk of serious outcomes from COVID-19.

The consortium, led by the University of Oxford, used linked anonymised GP records to develop a model, QCovid®, that used various factors to calculate risk of hospitalisation and death from COVID-19.

This information became invaluable in February 2021 when the model was used to identify 1.5 million high-risk individuals who needed to be placed on the shielded patient list so they could be prioritised for the vaccine.

The research was published in the British Medical Journal and Oxford University Innovation provided a reference implementation to demonstrate how the model works.

Oxford also made the QCovid® Calculation Engine source code available at GitHub in the interests of transparency, flexibility and accountability, and in line with government guidance on the use of open source code. This enabled the model to be used by interested researchers for academic purposes, enabling further potential societal benefits.

This ability to identify and protect those at high risk from COVID-19 demonstrates the power of data-driven population health management and proactive care.

8.4 Lessons learned

- Huge importance of timely access to high quality routinely collected data for analysis from primary care, linked to secondary care, mortality, Covid-19 infection, and vaccination data as this allowed tracking of the pandemic, identification of people most at risk of severe outcomes, analysis of uptake, effectiveness, and safety of interventions such as vaccination.
- Value of publishing protocol and early research findings to accelerate the acquisition of knowledge. In particular, the use of pre-prints, which are not peer reviewed with appropriate cautions around interpretation. The reason that this is important is because traditional peer review takes many weeks or even months and there is not sufficient time for this in an urgent pandemic situation, with a novel virus.
- How well different organisations/parties can work together around a central goal– including academics, clinicians, policy makers, data providers, members of the public. For example, we were able to progress the development, validation, and implementation of the QCOVID risk assessment tool over a period of months rather than years because of the coordinated, collaborative approach taken by these groups.
- Considerable opportunity to extend this approach to other non-COVID-19 contexts.

9 Dissemination

As noted above, research findings were disseminated in near real time, immediately as they were produced via:

- Meetings with the four UK CMOs, DHSC, NERVTAG, SAGE, JCVI, NICE, MHRA, RCGP, RCP.
- Timely press releases
- Papers published as pre-prints and as peer reviewed research papers in medical journals (see list above).
- Talks at conferences, both in person and online for diverse audiences including patients, policy makers, IT suppliers to the NHS, academic researchers, the Royal Colleges (particularly, RCGP, RCP, RCPsych) and the Academy of Medical Sciences.
- Together with the CMO's office and DHSC, we liaised with over 48 patient groups to communicate findings as they emerged.

10

10 Impact

The QCOVID risk assessment tool was developed to identify patients at risk of severe COVID-19 outcomes for interventions. It was implemented by NHS Digital in Feb 2021 to risk stratify the entire population of England adding 1.5 million people to the Shielded Patient List and it prioritised 800K people for early vaccination. It was also used to inform vaccine policy and deployment of novel COVID-19 therapeutics.

QCOVID also was used as a first-of-type exemplar for developing new standards for algorithmic transparency.

In delivering QCOVID, the research team worked with policy makers and the NHS to pioneer the first known precision scalable public health intervention internationally establishing a new and re-usable infrastructure/approach.

QCOVID was also implemented as a clinical calculator (www.QCOVID.org) for use by clinicians to personalise risk in order to improve decision making & guide interventions.

Below are three re-usable Figures produced by DHSC and NHS Digital to summarise the impact of QCOVID.

QCOVID used in the Pandemic

Department of Health & Social Care | University of Oxford | QCovid Risk assessment | NHS Digital

1. Led to **nationwide improvements in patient safety**: identified 1.5m high risk individuals for SPL addition, 820k offered vaccine earlier
2. Met the **highest standards of assurance** for patient safety
3. First known **precision public health intervention** of this nature in the world, leveraging the **unique power of NHS Data**
4. **Relieved burden** on the healthcare system at a time of intense pressure
5. Provides a **blueprint for the future**

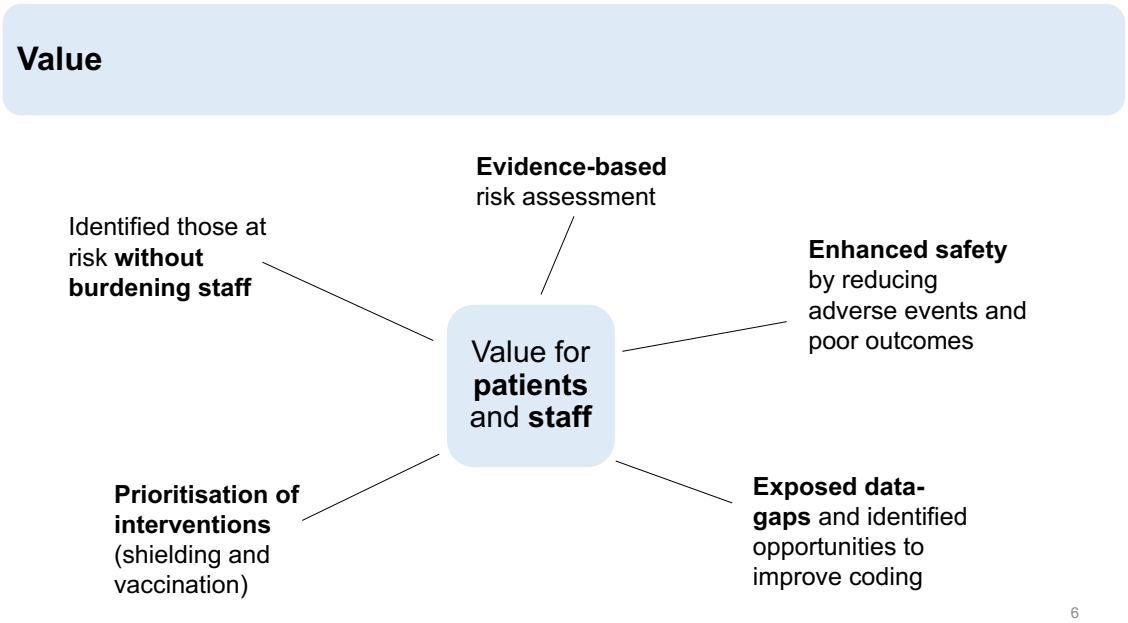
9

Spread: The first known **precision public health** intervention of its kind

Future applications of **population health** stratification:

- Other potential uses in the Covid-19 pandemic, e.g. **targeting treatments**
- Learning for **future pandemics**
- UK **Devolved Administrations**
- Use in wider health sector for **population health management**
- **International reach** – requests for use in Australia and Cambodia

7



The work was published as an NIHR impact case study.

11 Awards and recognition

QCOVID won 4 national awards listed below (with associated links to more detail):

1. Dr John Perry Prize, British Computer Society for outstanding contribution to NHS IT.
2. Florence Nightingale Award for Excellence in Healthcare Analytics.
3. Highly commended Health Service Journal Award Best Use of Technology
4. Royal College of General Practitioners COVID-19 Paper of Year Award for 2021.

QCOVID was included in the citation of the Damehood for Deputy COM Dr Jenny Harries in the New Years Honours list in 2022.

Dr Jennifer Margaret Harries OBE

Jenny Harries has devised, developed and implemented the clinical shielding policy to protect the clinically vulnerable and has worked through the Covid-19 pandemic to identify the group of those clinically extremely vulnerable. She has continued this work with the development of a national research collaboration to deliver a risk stratification tool, QCovid, led by Oxford University. She played a leading role in the UK's response to Ebola in West Africa, overseeing the introduction of the UK's Returning Workers Programme and most high-profile airport screening programme. She also led the successful response to the detection of Monkey Pox in the UK, as well as work on MERS and the Zika virus. Her incident response work extends to the National Breast Screening programme, the safe management of Hepatitis A during a vaccine shortage, and the public health professional response to the Novichok attack.

QCOVID was included in the citation for Prof Julia Hippisley-Cox's election as a Fellow of the Academy of Medical Sciences in 2023.

12 Intellectual Property (IP) and commercial adoption

The software to implement QCOVID in the NHS consist of the following 6 components:

1. Risk engine: QCOVID is a predictive algorithm which predicts short term adverse outcomes (hospitalisation or death) from COVID-19 infection. The algorithm is expressed as .NET core software.
2. Code library for clinical codes used to identify risk parameters: These are, in part, derived from codes licenced under CC-BY 4.0 from ClinRisk Ltd., and in part generated afresh. Changes, and new lists are owned by Oxford and published https://www.qresearch.org/data/qcode-group-library/
3. QCOVID® registered trademark owned by Oxford University Innovations
4. QCOVID domain QCOVID.org
5. QCOVID website QCOVID.org
6. Postcode-Townsend lookup table - background IP owned by University of Oxford.

Is the software registered as a medical device?

The software was registered with MHRA as a medical device in 2020 made available for use by suppliers who can integrate it into their own products and use it to supply services to the NHS until 2023. Oxford University Innovations have now ceased to be the manufacturer and a new commercial entity has been identified to be the UK manufacturer. Oxford University Innovations will be seeking NIHR licensing consent in Q1 2024.

What is new about your IP?

QCOVID predicts absolute and relative risks of COVID-19 outcomes providing a more nuanced approach to risk management. The prediction model software takes a set of inputs (age, sex, ethnicity, clinical conditions and other risk factors) and gives an absolute and relative risk of severe outcomes of interest. The analysis was undertaken using linked electronic health care records (the QResearch database and other linked data assets) covering a population of approx. 10m individuals in England during the pandemic.

How can the IP be used?

1. to inform clinical decision making regarding COVID risk management between a patient and clinician

2. to inform occupational health discussions

3. risk stratify populations to identify those at high risk for interventions such as shielding or vaccination or novel therapeutics

4. target recruitment into clinical trials -higher risk cohorts are likely to have higher event rates so theoretically selecting on this basis will increase power of trials and make them more efficient. Conversely lower risk patients may be suitable for vaccine challenge studies.

5. development of health economic models to inform policy development

What are the advantages of your IP and how does it improve on the present situation?

There is no other validated risk algorithm which can be used to identify high risk vaccinated patients for interventions.

Has the algorithm been updated?

Yes, the work covered by this report was for QCOVID1-3. A further version was funded by NIHR (QCOVID4) in 2022/3 to cover the Omicron wave and additional vaccinations. The web calculator has been updated accordingly.

13 Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: JHC reports grants from National Institute for Health Research (NIHR) Biomedical Research Centre, Oxford, grants from John Fell Oxford University Press Research Fund, grants from Cancer Research UK (CR-UK) grant number C5255/A18085, through the Cancer Research UK Oxford Centre, grants from the Oxford Wellcome Institutional Strategic Support Fund (204826/Z/16/Z) and other research councils, during the conduct of the study. JHC is an unpaid director of QResearch, a not-for-profit organisation which is a partnership between the University of Oxford and EMIS Health who supply the QResearch database used for this work. JHC is a founder and shareholder of ClinRisk ltd and was its medical director until 31st May 2019. In August 2023, ClinRisk Ltd was donated to Endeavour Health Care Charitable Trust and renamed to Endeavour Predict Ltd. Endeavour Predict Ltd produces open and closed source software to implement clinical risk algorithms (outside this work) into clinical computer systems. JHC was chair of the NERVTAG risk stratification subgroup and a member of SAGE COVID-19 groups and the NHS group advising on prioritisation of use of monoclonal antibodies in COVID-19 infection. CC reports receiving personal fees from ClinRisk Ltd, outside this work and was a member of the NERVTAG risk stratification subgroup. KK is supported by NIHR Applied Research Collaboration – East Midlands (NIHR ARC-EM) and the Leicester BRC. RHK was supported by a UKRI Future Leaders Fellowship (MR/S017968/1); KDO was supported by a grant from the Alan Turing Institute Health Programme (EP/T001569/1). KK is a member of SAGE. AS is a member of the Scottish Government Chief Medical Officer's COVID-19 Advisory Group and a member of AstraZeneca's Thrombotic Thrombocytopenic Advisory Group; both roles are unremunerated. RAL is a member of the Welsh Government COVID-19 Technical Advisory Group – un-renumerated. MGS reports grants from DHSC NIHR UK, grants from MRC UK, grants from HPRU in Emerging and Zoonotic Infections, University of Liverpool, during the conduct of the study, other from Integrum Scientific LLC, Greensboro, NC, USA, outside the submitted work, is a member of NERVTAG and attends SAGE COVID-19. AH is a member of NERVTAG and the NHS group advising on prioritisation of use of Monoclonal Antibodies in COVID-19 infection. JV is National Clinical Director for Diabetes and Obesity at NHS England and Improvement. FK is a member of the Northern Ireland Chief Medical Officer's Pandemic Modelling Group and Strategic Intelligence Group. JSN-V-T is seconded to the Department of Health and Social Care (DHSC), England. The views expressed in this manuscript are those of the authors and not necessarily those of DHSC or Her Majesty's Government.

14 Ethics approval

The QResearch® ethics approval was provided on 8th June 2020 by the East Midlands-Derby Research Ethics Committee [reference 18/EM/0400].

15 Data sharing

To guarantee the confidentiality of personal and health information only the authors have had access to the data during the study in accordance with the relevant licence agreements. Access to the QResearch data is according to the information on the QResearch website (www.qresearch.org). The full model, model coefficients, functional form and cumulative incidence function, is published on the QCOVID.org website.

https://www.QCOVID.org/Home/Algorithm.

16 Acknowledgements

We acknowledge the contribution of EMIS practices who contribute to QResearch® and EMIS Health and the Universities of Nottingham and Oxford for expertise in establishing, developing or supporting the QResearch database. This project involves data derived from patient-level information collected by the NHS, as part of the care and support of cancer patients. The data is collated, maintained and quality assured by the National Cancer Registration and Analysis Service, which is part of Public Health England. The Hospital Episode Statistics data, SARS-CoV-2 results and civil registration mortality data are used by permission from NHS Digital who retain the copyright in that data. NHS Digital and Public Health England bears no responsibility for the analysis or interpretation of the data.

17 Appendix 13 EAVE II Patient and public involvement with QCOVID

Contents

18 1 Project summary

18.1 1.1 Objective

The main research objective of the QCOVID project is:

"To derive and evaluate a risk prediction tool to estimate short term risks of adverse outcomes from COVID-19 in adults and children which can be used to risk-stratify the general population."

QCOVID 1 was mainly used to inform shielding and vaccine prioritisation policy. QCOVID 2 and 3 modelled the outcomes of interest (COVID-19 hospital admission and death) for unvaccinated and vaccinated populations respectively. QCOVID 4 is being used to predict outcomes for people who have received third, and fourth, doses of a COVID-19 vaccine.

18.2 1.2 Design

The QCOVID prediction tools for acute COVID-19 hospital admissions and deaths was developed using 1205 GP practices in England, held in the QResearch database. The algorithm was trained on a cohort of 6.08M people, and validated on a subset of 2.17M people. The final models have been externally validated using routinely collected GP data from other sources, including:

- **Office for National Statistics (ONS) Public Health Linked Data Asset**: England, 40.1M people
- **EAVE II**: Scotland, 5.4M people
- **SAIL**: Wales, 3.2M people.

Validation within the EAVE II team was carried out in conjunction with the project's Public Advisory Group, described in Section 3.1.

19 2 Report summary

This short report covers EAVE II's PPI activity within the QCOVID project. This includes both project-wide and EAVE II-specific research and outputs.

The report covers PPI structures and involvement of the EAVE II Public Advisory Group, key undertakings and a summary of the resulting discussions, and consideration of what an ideal prediction model may look like from a public and patient perspective.

20 3 About EAVE II

The "Early Pandemic Evaluation and Enhanced Surveillance of COVID-19" (EAVE II) project was first set up to track the COVID-19 pandemic and vaccines for people in Scotland, by using routinely collected health data.

As well as contributing to external validation of the QCOVID risk prediction tool, EAVE II uses QCOVID risk indicators in its own surveillance and research.

Find out more about EAVE II

20.1 3.1 EAVE II Public Advisory Group (PAG)

The EAVE II PAG is made up of a diverse, representative range of fifteen patient and public contributors across Scotland, England and Wales by age, sex, ethnicity, occupation and socioeconomic status, interests and life experience.

The group includes some people who have had COVID-19 or care for those who have, as well as clinically extremely vulnerable people who were shielding. It also includes people with additional physical or mental health conditions, and physical or learning disabilities.

The group meets every 4-6 weeks on Zoom to discuss different projects using EAVE II data, including the QCOVID project. They also carry out written or reviewing work by email. Two members of the group are PPI Leads who also sit on the EAVE II Steering Group.

21 4 PPI activities

The EAVE II PAG has been involved with the design, dissemination, analysis interpretation and evaluation of the QCOVID project in the context of EAVE II data. Involvement with dissemination of QCOVID was restricted to reviewing summaries in plain English of publications produced by the EAVE II team – further collaboration on dissemination of other key findings from QResearch are detailed in Appendix B.

The PAG were also given the opportunity to read and comment on the Citizen's Jury Report on QCOVID, carried out by Ipsos and Professor Sarah Cunningham-Burley in April 2022 on behalf of the Scottish Government.

This report identified five main themes of discussion (efficacy and accuracy, data security, transparency and communication, targeted support, and justification), as well as acceptable principles of use for the following four types of models:

1. Clinical tool for assessing individual risk.
2. Public-facing tool for assessing individual risk.
3. Population-level tool using non-anonymised data.
4. Population-level tool using anonymised data.

The PAG did not respond to comment on this report, but separately discussed model efficacy and accuracy and justification for use in May 2022, as outlined in Section 4.3 and 4.4 of this report.

21.1 4.1 Design – QCOVID 2/3 Risk Prediction Tool

In September 2021, members of the PAG were invited to review the newly launched QCOVID 2/3 tool, and accompanying online risk assessment documentation, from a public user perspective.

QCOVID™ risk calculator (QCOVID-test.azurewebsites.net)

Coronavirus (COVID-19) risk assessment - NHS Digital

PAG members were provided with a Word document containing information from the main content of the online tool, as well as links to the tool and supplementary information.

We invited the group to provide feedback on the following aspects of the tool:

- the layout and design
- the language
- if it makes sense to a public audience
- if you think members of the public would be interested in using it
- any other comments/feedback you have.

Four of the nine PAG members participating with the EAVE II project in September 2021 took part in this work. A full copy of the four sets of responses is available in Appendix A. Their responses can be summarised as follows.

4.1.1 Layout and design

Two users felt that the layout responded well on phone and PC, and was modern and legible, without any superfluous elements. The hyperlinks to other sites in the risk assessment information was found to be useful, as was the provision of FAQs and additional details with the online tool. However, one user found the FAQs too complicated.

Two users found the layout too formal. One commented that the public-facing version of the tool should be redesigned completely. One user felt that using visual resources, particularly to explain the risk score, would be useful.

Agreement to a user license was a source of confusion. One PAG member was not sure if they should agree to this before being able to proceed, or if it was only designed for academic/clinical institutions. Overall, PAG members felt that the tool had been designed for academic users.

4.1.2 Language

Two users found the language to be far too technical and made reference to specific statistical phrases including “cumulative calculation” and “absolute and relative risk”. Two users found it understandable as experienced PPI contributors but commented that it may be too technical for other users.

4.1.3 Understandability

One user tested the tool and was not able to understand their results, despite being research-literate. They felt that the tool would only be understandable to a very small section of the public. As mentioned above, another user felt that the calculation’s understandability would be significantly improved with a visual guide. One user used the tool for themselves and their spouse but felt concerned by the results (which calculated their COVID-19 risk as high).

4.1.4 Utility

One user felt that it was a useful tool to have available to the public. The remaining three users felt that it would be of very limited public use. The remaining three users felt that it would only be of interested to a very small section of the public, who are highly motivated to understand their own risk and sufficiently literate to do so.

Two users felt that the tool could be made more useful by making references to specific patient groups clearer. For example, in the section on cancer and immunosuppressants it is not clear that this refers only to people with cancer, rather than people taking immunosuppressants for other reasons. For the risk calculation itself, one user felt it would be useful to contextualise the results in terms of people from the same patient or age group (e.g. transplant patients).

4.1.5 Additional comments

One PAG member did not feel that the distinction between different tool iterations (i.e. QCOVID 1/2/3) was clear. Another felt that it should be made clear to public users that the risk score did not necessarily equate to permanent risk; some people are acutely unwell and then recover completely. One member felt that a separate project should be undertaken to make this tool available to the public, due to the influence of factors which cannot be captured by data.

21.2 4.2 Analysis interpretation

The PAG invited senior analyst Dr Steven Kerr (SK) to discuss provisional QCOVID 2/3 project results with them in May 2022. In this meeting, EAVE II PPI Coordinator Dr Lana Woolford (LW) gave a brief reminder of the outcome of testing the online tool design (described in Section 4.1), before SK gave an overview of the QCOVID project, the difference between the models, how well the current model performs, and how the model has been used to inform policy in Scotland and the UK.

Following this, the PAG asked questions and interpreted results from their perspective, before reflecting on the wider public and PPI context of the project (discussed in Section 4.4).

Before considering the results, the PAG sought clarification on the following areas.

Topic	Question	Response from SK
Nomenclature	What does an 'event' represent in this model?	There are two outcomes in this model – hospital admission and death.
Inclusion of variables	Are third doses factored into QCOVID 3?	We are testing whether the QCOVID 2/3 model works for third doses, but they weren't incorporated into the model. QCOVID 4 includes third and fourth doses.
Model vs reality	What happens if there is a big gap between observed and expected events?	There are several performance metrics that can be used, but here it's less of an issue as we were mainly interested in ordering groups by risk, rather than getting the absolute risks correct.
Model sensitivity	Is it better to over-predict or under-predict risk?	There is a lot of debate about this in the literature. We tend to err on the side of caution and over-predict.

SK explained that there are some issues with evaluating the QCOVID 2/3 model in a Scottish context. This includes computation time, a lack of ethnicity data and some other missing variables, as well as

data in different categories or formats to the original model. This means analysts have to resort to approximations.

QCOVID 1 was not used to inform shielding categories in Scotland due to infrastructure and data governance issues, as well as concerns over how to model the missing ethnicity data. The Scottish Government also decided against using QCOVID 2/3 due to cost and non-inclusion of booster doses. However, the EAVE II team use QCOVID risk categories frequently to control for underlying conditions in our analysis.

To inform shielding categories in Scotland, the Scottish Government used influenza risk categories.

4.2.1 Discussion

The PAG were surprised by the length of computation time needed (one month) and asked what causes this change between QCOVID1 and 2/3. This was caused by the introduction of competing risks, which are calculated timewise (e.g. prediction changes daily). One PAG member asked whether it was necessary to include competing risks, given that the majority of variables used do not change on a daily basis.

One PAG member asked about identifying the control group for risk prediction. How do we identify unvaccinated people? SK explained that this has been an issue throughout our research, but there are still enough unvaccinated people to use this cohort as a control group.

Finally, a PAG member asked about how deaths due to COVID-19 are defined. How many people would have been likely to die during this period anyway? SK explained that there are clear spikes in excess deaths that correspond to waves of infections, so it's likely that the majority of deaths due to COVID-19 were correctly attributed. However, he acknowledged that the higher risk of COVID-19 death amongst older people and/or people with multiple underlying health conditions, and the extent to which hospital services were stretched by the pandemic, means that defining deaths 'with' or 'from' COVID-19 is still debated in the literature. To some extent, these definitions need to be decided at a policy level.

The PAG also discussed the lack of ethnicity data in Scotland and how this is an issue, since other evidence shows that ethnic minorities have been disproportionately affected by the pandemic.

21.3 4.3 Project and PPI evaluation

As part of the May 2022 meeting, the PAG also evaluated aspects of broader project decision-making from a public/patient perspective.

We discussed the following questions:

1. What would be useful in a risk model for the public?
2. Better or worse: a Scottish model or a UK-wide one?
3. From hindsight: what PPI activities should we carry out?

The discussions are summarised in the sections below.

4.3.1 What would be useful in a risk model for the public?

One PAG member asked why the Scottish Government opted to use flu categories for creating shielding lists. LW explained that, prior to development of QCOVID, the UK's CMOs constructed a preliminary shielding list based on flu risk groups (as the closest relevant condition where modelling had already been carried out). This was retained in Scotland when QCOVID 1 was not adopted.

COVID-19 deaths, excess deaths and how these are defined were raised as areas for consideration in future models. One PAG member asked whether excess deaths during peak waves of the pandemic

were partly caused by a lack of access to healthcare for other reasons, rather than by COVID-19. LW explained that other members of the EAVE II team are looking into this.

Another PAG member felt that a simple model which is inexpensive, quicker to implement and easy to run would be more useful for future pandemics than an expensive, complex model.

Finally, a PAG member raised the issue of indirect consequences of COVID-19 – for example, the time between first accessing healthcare and diagnosis for other conditions. Are people advancing to untreatable stages of cancer due to COVID-19 related healthcare disruption? Could we factor this type of information into risk prediction models?

4.3.2 Better or worse: a Scottish model or a UK-wide one?

One PAG member asked why Scotland needs a specific model but commented that if it is cheaper and faster to run, and takes account of different ethnicity data, then it is worth producing.

One PAG member asked whether all of the UK teams could be involved in developing an algorithm that also works for Scotland, as this may help with validation due to the smaller population size in Scotland. SK explained that some collaborative work has been done through the DaCVaP 1/2 project, but it can be difficult to train models between nations as we are not allowed to share some kinds of data.

This PAG member also commented that differences in policy between nations have been difficult to acclimatise to (e.g. being told in England that it is up to the individual to decide whether to shield or wear a mask).

4.3.3 From hindsight: what PPI activities should we carry out?

The PAG felt that PPI should be embedded throughout the process of developing a Scotland-specific model. A model could be co-produced by discussing what is important to different communities or groups of patients about COVID-19 and their own risk. Feedback loops are an important part of this process, so that we can understand where public input has made a difference.

One PAG member felt that it would be useful to have some flexibility in the score in terms of updating it over time, as people's circumstances and risk change over time (even if not daily).

22 Discussion

The EAVE II PAG have carried out PPI with the project at four stages of the research cycle: design, dissemination, analysis interpretation, and evaluation. Due to the timing and sensitivity of the project and data, EAVE II PPI has been restricted to involvement with communications or with validation of the prediction tool by the EAVE II team.

As with other prediction tools which make use of EAVE II data, PAG members who tested the online QCOVID tool were concerned about the context of the results (e.g. whether they would form part of shared conversations between patients and healthcare staff), and whether they would generate anxiety amongst patients. There was general consensus that the online tool had been created for a technical audience and may need significant editing so that the language is accessible for the public.

Collaborating on disseminating key patient-relevant results allowed for a wider variety of public views to be incorporated into infographic and publication summary production in a relatively short time frame. On reflection, we did not make full use of this collaboration, as the EAVE II PAG focused largely on the Scottish context. It would be useful in the future to share learning with other PPI groups involved with the wider QCOVID project, as well as establishing feedback loops with researchers regarding PAG input on the QCOVID online tool.

As with other prediction modelling projects, PAG discussion of the QCOVID project and results focused around definitions and inclusion criteria, model complexity versus accuracy, and how individual patients and their outcomes are represented in the data. Specific to this project, we also

discussed the relative benefits of Scotland-specific versus UK-wide models. The PAG acknowledged the challenges of collaboration and the practical benefits of having a model tailored to Scottish data, but also commented on the difficulty of accepting and explaining pandemic measures (including priority lists) which vary geographically.

In the future, the PAG felt that PPI should be embedded in the development of national risk models from the beginning, and that the model should have the capacity to be updated with new risk scores as people's individual risks change (e.g. due to changes in disease, vaccination status, treatments and so on). A model developed for Scottish data was seen as a practical compromise in the situation where data are collected in different formats, and with varying quality or missingness, across the four UK nations. Ultimately, it may be better to have a collaborative approach with unified data collection criteria. As the pandemic has progressed, and there is a potential for more excess deaths to be cause by healthcare disruption than by SARS-CoV-2 infection itself, some PAG members felt that definitions of COVID-19 deaths, and measures of healthcare disruption, should be incorporated into models where possible.

23 Appendices

23.1 Appendix A – Full responses from testing the online QCOVID 2/3 tool

The four PAG members that tested the QCOVID 2/3 online public-facing tool gave the following comments.

Member 1 annotated the document (QCOVID Website member 1) and gave the general comments below.

- I am confused between public use and licensed use. Why would a member of public agree to the licence?
- It is a very good tool for members of the public to calculate their risk
- What I did not find is that many people with covid have suffered severe outcomes and stayed home to recover and have recovered after experiencing those outcomes between two to 4 weeks and in some cases even more. So there should be some mention of this.
- The language is still academic. Have made some comments
- I suggest just using QCOVID as main heading on its own and then have sub headings Risk Calculator
- I find the risk assessment hard to grasp and as I am more of a visual person , I would have liked to see some info graphics.
- The further questions answers could have been kept simpler.

Member 2 annotated the word document (QCOVID Website member 2) and gave the general comments below.

This was an interesting document, my feedback is as follows

- the format/layout

The format and layout was very formal, dry and not user/ public friendly. I appreciate at the moment it's used by clinicians and researchers but I feel it would need to be completely reworked if targeted at members of the public as well.

- the language

The language was very technical, including "absolute and relative risk", "evidence based model", "cumulative calculation" etc. I am fairly research literate but was struggling to understand. When I ran my own personal calculation I didn't really understand what the results meant.

- if it makes sense to a public audience

I think this would make sense to a very small section of the public, which may in fact be the people who would want to use the tool! As the language used was so technical I didn't feel it was inclusive at all. One of the questions was about cancer treatments and immunosuppressants, I initially took that to mean people who were immunosuppressed who had cancer and other conditions. It wasn't till I looked at the list of medications that I realised they were only interested in cancer. Given the results of the recent OCTAVE study I feel this is shortsighted. Also the recently reported RECORDER project showed that people living with rare, rheumatological diseases had a higher risk from COVID, including death and hospitilisation.

- if you think members of the public would be interested in using it

I am not sure if they would! It mentions using the tool as part of a conversation between clinician and patient but it's such a struggle to get appts at the moment. In my experience GP's don't have the knowledge or inclination to discuss COVID risk with people. In secondary care it's a real post code lottery, as someone who is shielding (and was initially missed off the shielding list) my Consultant has not been in touch to discuss any aspect of my personal risk but I know of people who have had direct communication from secondary care. What would be the purpose of members of the general public using it? Now we have "freedom day" and the official end of shielding etc how could I use the results to protect myself from increased risk? Will it end up putting more responsibility on people at higher risk who we know have less resources and privilege to overcome their increased risk? What would be the unintended consequences of putting this calculator out as it stands?

- any other comments/feedback you have

For many COVID has been an emotional rollercoaster and experience, it's something that I am acutely aware of as I am about to embark on some patient led qual research looking at peoples experiences of shielding and the way the notification process was handled etc. I realise I sound like a broken record but my concern is that tools founded on routinely collected data are devoid of nuance, tears and other emotions, big data requires deep data. Using tools like the Townsend score are problematic as although they may be the "best indicator" they are far from perfect and the factors not incorporated into QCOVID (behaviour, occupation) can have a significant effect.

I appreciate the opportunity to comment on this but there is a fundamental problem with retrofitting patient and public involvement and insight after a tool is developed. It's telling that the CMO asked "Leading academics, clinicians and scientists" but didn't think to involve PPI from the start. I have used risk prediction tools in the past when I was a nurse, it never occured to me that what I was doing was reducing people to a list of characteristics, it just feels very uncomfortable. I feel if this was to be made available to the general public it would have to be part of a specific project to do so, looking at the lay out of the calculator, and the understandability of the results. Ensuring that the output met the needs of the people who may use it.

Member 3 annotated the word document (QCOVID Website member 3) and gave the general comments below.

Many thanks for sharing the email links and MS Word document. I initially spent time reading and editing the Word document supplied and altered same using the Review function of Word. I attach my version of the document to which I have suggested a number of potential changes.

Thereafter, I visited the risk assessment site https://digital.nhs.uk/coronavirus/risk-assessment (that explains in some detail the background of the research arriving finally at the QCOVID algorithm). Subsequently I visited the QCOVID test site (where an individual patient can assess his absolute risk scores associated with COVID) : https://QCOVID-test.azurewebsites.net

I understand that you are looking for feedback on:

- the format/layout

  I found the format and layout of the web site easy to read with a very legible font size together with strong links that allow a reader to move throughout the site backwards and forwards to those areas of greatest personal interest without getting lost

- the language

  I consider that the language adopted was acceptable to both academics and members of the public. Neither did I think that the writer was being condescending to enable non-academic readers to understand the text.

- if it makes sense to a public audience

  The sites were easy to read and understand and I did use the QCOVID tool to assess risk levels for both my wife and I. It was simple to use (even if the result was a little concerning). The very thorough detail provided on behalf of patients within the web sites could be particularly useful

- if you think members of the public would be interested in using it

  Yes I do think that some members of the public would wish to use the algorithm in order to get some idea of personalised risk levels. The number of such users is likely to be very limited due partly to a lack of awareness of its availability and partly due limited interest in academic papers

- any other comments/feedback you have

  I found the relationships between QCOVID 1, 2 & 3 a little confusing on first reading and was unsure which I was using when seeking to obtain a personalised risk assessment. Perhaps it would be useful to consider integrating the tools to obtain and to adopt just one single QCOVID tool which has a pathway through that leads a user to the correct area dependant on use during the deployment of the single algorithm (similar to the approach adopted by other software companies like Microsoft etal). There would be only one QCOVID that was updated as more data becomes available thereby simplifying its long term use.

Member 4 gave the general comments below.

It's beautifully designed, looks very modern and is responsive (opened it on my old iphone too).

There no superfluous elements or sections. For me, an experienced public contributor, the language is on the appropriate level – balanced between academic and lay. Other people may have problem comprehending some points, though someone inquisitive would likely read FAQ's.

The only aspect that puzzles me is the purpose of the tool. While it certainly useful for researchers, doctors and the like, I don't see a reason why a lay person would make a calculation, unless someone really interested in the topic or paranoid about their chances of infection/death from Covid-19. I think that the general attitude is to forget about Covid-19 and move on. It would also be useful to see results referenced to your age group or patients with the same comorbidities.

23.2 Appendix B – Further collaboration on dissemination

The EAVE II PAG were also involved with two publications linked to QResearch, both containing results which may directly impact on public policy and decision-making. The publications are related to the safety profile of COVID-19 vaccines available in the UK.

To carry out this work, we collaborated with the QResearch analytical team and PPI Coordinator (Dr Sharon Dixon) at the University of Oxford. While we produced a summary in plain English of the publications lead by the University of Oxford, they involved the Applied Research Collaborations East Midlands (ARCEM) PPI panel, as well as a group of immune-compromised patients, to review infographics produced by the University of Edinburgh Communications Team. This helped to produce public communications which reflected the collaborative nature of the research.

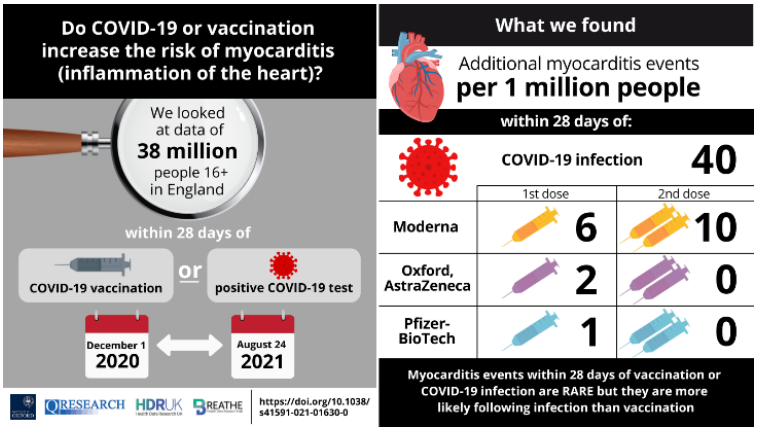


Figure 1 Infographic for the QResearch publication on potential heart inflammation (myocarditis) side effects from COVID-19 vaccines

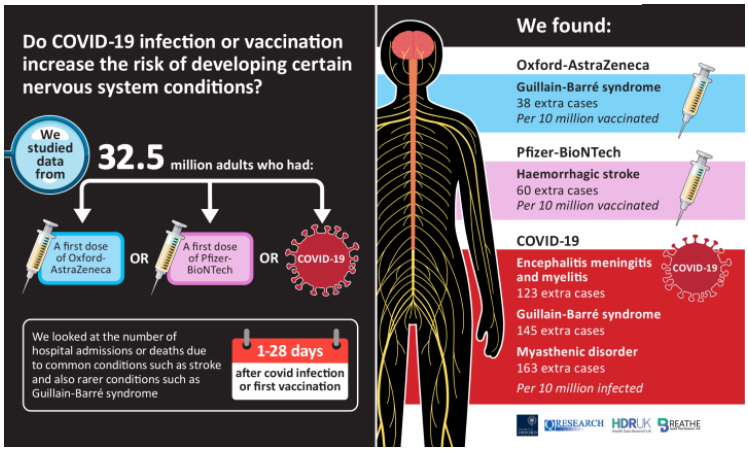


Figure 2 Infographic for the QResearch publication on potential neurological side effects from COVID-19 vaccines

Read the summary for the QCOVID vaccine safety paper on neurological conditions

Read the news entry for the QCOVID vaccine safety paper on myocarditis

23.3 Appendix C– NIHR peer review and responses

NIHR submitted this report for peer review in January 2024, with three academic reviewers and one PPIE review. The original reviews are appended to this report (see pages 40 onwards). For ease of reference, our response to the peer review submitted to NIHR on 10.05.2024 is presented below

Reviewer 1

We thank reviewer 1 for their very positive appraisal of our final report and excellent ratings across all five domains. There were no specific issues to address in the review.

Reviewer 2

We thank reviewer 2 for their critique and were pleased to see three domains rated as good and two as excellent.

In (2c and 5c) They mention that there may be opportunities for further validation or refinement which we would like do subject and we would welcome advice from NIHR on how this research could be resourced.

We are engaging with PPIE to further improve he accessibility of the online tool in diverse populations through a partnership with the NIHR ARCEM team at Leicester University, which we will address the recommendation relating to this in (3b)

Reviewer 3

Thank you to reviewer 3 for their comments which are supportive of our work and associated report with three domains rated as excellent and two as good.

In (3c) the reviewer states that there is no evidence or plans to exploit the IP although this is covered in section 12 of our report. Furthermore, Oxford University Innovations have identified a Community Interest Company with the technical skills and resources to become medical device manufacturer. We are also pleased that there is at least one potential commercial license in the late stages of negotiation with a global supplier.

PPIE review

We are grateful to the PPIE reviewer for their insightful and thoughtful summary and also for rating all five domains as excellent. In response to the question in (3a), during the intended use of the tools is by clinicians with patients rather than the general public alone.

Response prepared by Professor Julia Hippisley-Cox, Chief Investigator, on behalf of the team.

Date: 10.05.2024

Final Report Peer Review Form Policy Research Programme (PRP)

Thank you for agreeing to review this draft final report for the NIHR Policy Research Programme (PRP).

We very much appreciate you taking the time to undertake this vital part of the research process.

If you have any questions or experience any issues with submitting this form, please contact the PRP Team on 020 3692 7875

PRP Reference Number: COVID-19 Risk Prediction Tool

Project Title: COVID-19-Risk Prediction Tool

Please state your Reviewer ID *

1

Confidentiality

Once you have completed this form, your responses will be used by the Policy Research Programme (PRP) to review the project's findings and assess its outcomes.

Your completed responses are considered confidential, and are therefore exempt under the provisions of the Freedom of Information Act (section 41).

Receipt of this document from the PRP Programme, and your subsequent completed return, form a 'mutual confidentiality agreement' covering your completed responses. This information will not be released without prior consent (except to the parties named below) unless required by law. To read more about our commitment to data security and confidentiality, please consult our privacy policy.

Please treat this report and the associated application form as **confidential.**

How we will use your review

This form will be passed:

- (unattributed) to the Chief Investigator of the final report you are reviewing with the ratings summary and any conflicts of interest removed (questions 7 and 8 respectively). Please ensure

that you do not include any comments which you would not want to be seen by the Chief Investigator or which could identify you as the reviewer.
- (in its entirety) to designated individuals of the Department of Health and Social Care, who will also be made aware of your name, institution and area of expertise. These individuals will learn your name in confidence.

Using this Form

Your expertise and experience have been recognised in asking you to review for us and both the researchers and colleagues at the Department of Health and Social Care would benefit from your comments.

Please rate how the report addresses each of the criteria in the relevant sections below. The prompts are intended to help you focus on the areas addressed by the criteria, but please feel free to comment on additional aspects which you consider to be relevant.

Patient and public involvement in peer review (information for lay reviewers)

Additional information and guidance for patients, service users and carers on peer review is available from the PPIE section of the NIHR website.

Additional information for public reviewers is available - Guidance for public reviewers of research funding applications.

Conflict of Interest

We should know about any competing interests that referees may have. Are you aware of any potential competing interests that you may have? If you are in any doubt about any potential competing interest then please declare it. We will not reject your opinion simply because you declare a competing interest, but we would like to know about it, please.

Do you consider yourself to have a conflict of interest with the applicant(s) or institution? *

- ( ) Yes
- (•) No

If yes, please give details (max 100 words)

Reviewer Expertise

Please indicate the nature of your expertise.

Please select *

Researcher in a broadly related field

If the options above do not adequately capture the nature of your expertise, please briefly provide details in the box below (or use it to give us more detail about your expertise if you wish). Max 20 words:

Were you in involved in the peer review of the original application for funding for this piece of work?

Wherever possible, you will be sent a copy of both the original application form and the research specification that this application responded to, for reference.

*

- ( ) Yes
- (•) No

We would be grateful if you would provide us with your opinion on each of the following aspects of this study:

1. Evidence that the findings/outcomes of this research are relevant to the issues specified in the original research specification and reflect the programme of work described in the application form *

A) Does the research reflect the overall scope and aims outlined in the application form and do the findings inform the original research questions?

B) Does the report demonstrate a clear understanding of the policy context of the question(s) and are the findings/outcomes clearly linked to this?

C) Are the findings/outcomes of this research placed in context of previous relevant research in this area such that added value is immediately evident?

(max 500 words)

The relevance of the outcomes of the research to the core scope – to develop a way of identifying those groups most at risk of serious outcomes from covid-19 – is clear, and evidenced through the wide practical implementation and impact of the tools.

The policy context, and tight linkage to this throughout, is well demonstrated. The work represents a unique confluence of the fast-moving circumstances of the pandemic and the advantages of harnessing large routine datasets using contemporary prediction modelling approaches, and as such the added value of the work is immediately evident.

2. Effectiveness of the research design and work plan (including methods of data collection and analysis) in delivering high quality, fit-for-purpose findings/outcomes for policymakers *

A) Did the research design and methodology prove appropriate to deliver the work described in the application?

B) Were the analyses conducted appropriate in terms of being able to draw robust conclusions?

C) In light of the findings/outcomes presented, are there any particular strengths and/or weaknesses of the research design or analyses chosen?

(max 800 words)

The methodology is evidently anchored throughout in the core gold standards of developing and validating clinical prediction models, including the reporting of a range of performance measures including calibration, and the importance of external validation and updating to support the application of models in specific settings over time. The robustness of the intricacies of the methodological approaches have already been subject to wide independent scrutiny as part of the body of published work described in the report, and has been noted to stand out amongst the multitude of covid-19 related prediction models as representing higher quality.

A particular strength is the consideration of the more translational aspects of how the tools are used clinically and their findings communicated and discussed with patients – an area of the clinical prediction model field which is essential to clinical use, yet remains widely neglected in the field. Indeed, some of the findings outlined on this aspect have relevance beyond the QCOVID model.

3. Quality of research findings/outcomes *
3a. General

A) Has this research yielded clearly defined and appropriately described findings/outcomes?
B) Are the conclusions logical and well thought out, and do they reflect the evidence presented in the report?
C) Can policymakers have confidence in the quality of the findings presented?

(max 600 words)

The primary output, i.e. the QCOVID tool and its implementation, is well described and as per the above robust methodology, policymakers can have confidence in its quality which has been variously tested.

3b. Patient and public involvement *

A) Where applicable, was there appropriate patient and public involvement in this research?
B) Did actual levels of involvement reflect those set out in the research application?
C) Could a greater emphasis on patient and public involvement have improved this study?
D) Is there evidence that findings will be shared with patients and the public (or have findings already been shared)?

(max 500 words)

There was extensive PPIE embedded in this work, which overall engaged 48 relevant organisations. Helpful specific examples are given of the practical differences this input made to the work. Findings have already been shared widely with patients and the public, and outputs such as the provided infographic likewise appropriately involved PPIE in their development. I do not think that any greater emphasis on PPIE could have further improved this work.

3c. Intellectual property *

A) Where applicable, are you able to identify any intellectual property (IP) produced or improved on during the course of this research?
B) Is there evidence of any plans to protect or exploit any such IP?

(max 500 words)

The IP is clearly detailed in the report; the QCOVID software is registered as a medical device and the report states a new commercial entity have been identified to be UK manufacturer.

4. Likely impact of the research on policy and/or practice *

A) Does the research described in this report have the potential to impact on health care and/or social care and/or public health policy and service delivery?
B) Does this research add to the knowledge base on health and well-being? Does the research add value or advance what is already known in this area?
C) Have target audiences been identified and effective methods of disseminating this research proposed to maximise impact?

(max 500 words)

As already alluded to, this project is somewhat unique in that in the context of the pandemic, the pathways to implementation and impact were proceeded in a highly accelerated manner to respond to the clinical needs of the population. As such, undeniable impact on service delivery and policy has already been achieved including to inform shielding and vaccine prioritisation policy.

5. The value of the output relative to cost (if cost of research provided) *

A) To what extent is there evidence that the level of resources used to complete this study was appropriate and justified?
B) Has the research provided adequate outcomes for the funds spent?
C) If the researchers have suggested that any financial benefits may arise from their work, please indicate how realistic you feel these might be.

(max 500 words)

I understand the total PRP requested funding was £127,269.00. I would suggest that the outputs and impact of this work represent outstanding value for money.

6. Suggestions for improvement to the research *

A) Do you have any thoughts on how this research might have been improved? If so, please indicate whether you see these as critical factors.

(max 300 words)

This is a high impact, and indeed award-winning body of work, delivered in challenging circumstances and at pace, for which I commend the authors and have no additional suggestions.

7. Rating Summary: *

Considering your answers to the questions above, please rate how well this final report addressed each of the criteria.

	Excellent	Good	Fair	Poor
Evidence of a clear focus on the issues specified in the research specification and the work described in the application form	☑	☐	☐	☐
Quality of the research design and work plan including methods of data collection and forms of analysis in terms of work delivered	☑	☐	☐	☐
Quality of research outcomes	☑	☐	☐	☐
The value of the output relative to cost	☑	☐	☐	☐
Likely impact of the research on policy and/or practice	☑	☐	☐	☐

Thank you

Thank you for completing this form. Please use the submit button below to confirm your responses.

Final Report Peer Review Form Policy Research Programme (PRP)

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We very much appreciate you taking the time to undertake this vital part of the research process.

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Project Title: COVID-19-Risk Prediction Tool

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2

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- (in its entirety) to designated individuals of the Department of Health and Social Care, who will also be made aware of your name, institution and area of expertise. These individuals will learn your name in confidence.

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Conflict of Interest

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Do you consider yourself to have a conflict of interest with the applicant(s) or institution? *

- ( ) Yes
- (•) No

If yes, please give details (max 100 words)

Reviewer Expertise

Please indicate the nature of your expertise.

Please select *

Researcher in a broadly related field

If the options above do not adequately capture the nature of your expertise, please briefly provide details in the box below (or use it to give us more detail about your expertise if you wish). Max 20 words:

I specialize in prediction modeling, AI, and machine learning.

Were you in involved in the peer review of the original application for funding for this piece of work?

Wherever possible, you will be sent a copy of both the original application form and the research specification that this application responded to, for reference.

*

- (●) Yes
- ( ) No

We would be grateful if you would provide us with your opinion on each of the following aspects of this study:

1. Evidence that the findings/outcomes of this research are relevant to the issues specified in the original research specification and reflect the programme of work described in the application form *

A) Does the research reflect the overall scope and aims outlined in the application form and do the findings inform the original research questions?

B) Does the report demonstrate a clear understanding of the policy context of the question(s) and are the findings/outcomes clearly linked to this?

C) Are the findings/outcomes of this research placed in context of previous relevant research in this area such that added value is immediately evident?

(max 500 words)

A) The research appears to reflect the overall scope and aims outlined in the application form. The findings align with the original research questions, particularly regarding the development and evaluation of a risk prediction tool for COVID-19 outcomes. The outcomes directly inform the objectives set forth in the application, demonstrating coherence and alignment with the initial research goals.

B) The report demonstrates a clear understanding of the policy context surrounding the research questions. The findings and outcomes are effectively linked to this context, providing valuable insights for policy development and decision-making in public health.

C) The findings and outcomes of this research are adequately contextualized within the broader landscape of relevant research in the field. By building upon existing knowledge and methodologies, the research adds value to the current understanding of COVID-19 risk prediction and management. The incorporation of previous research findings enhances the credibility and significance of the study's conclusions, highlighting its contributions to the field.

2. Effectiveness of the research design and work plan (including methods of data collection and analysis) in delivering high quality, fit-for-purpose findings/outcomes for policymakers *

A) Did the research design and methodology prove appropriate to deliver the work described in the application?

B) Were the analyses conducted appropriate in terms of being able to draw robust conclusions?

C) In light of the findings/outcomes presented, are there any particular strengths and/or weaknesses of the research design or analyses chosen?

(max 800 words)

A) The research design and methodology appeared appropriate to deliver the work described in the application. The QCOVID project utilized linked electronic health records and engaged with patient advisory groups, ensuring a comprehensive approach to data collection and analysis.

B) The analyses conducted were appropriate in terms of drawing robust conclusions. The use of predictive algorithms and risk assessment models allowed for thorough evaluation of COVID-19 outcomes, providing valuable insights for risk management and policy development.

C) In light of the findings/outcomes presented, strengths of the research design include its reliance on large-scale electronic health records, which enabled the assessment of COVID-19 outcomes in a sizable population. However, weaknesses may include potential limitations in data accessibility or representativeness, which could affect the generalizability of the findings. Additionally, while the chosen analyses were appropriate, there may be opportunities for further validation or refinement of the predictive models to enhance their accuracy and applicability.

3. Quality of research findings/outcomes *

3a. General

A) Has this research yielded clearly defined and appropriately described findings/outcomes?
B) Are the conclusions logical and well thought out, and do they reflect the evidence presented in the report?
C) Can policymakers have confidence in the quality of the findings presented?

(max 600 words)

A) Yes, the research has yielded clearly defined and appropriately described findings/outcomes. The QCOVID project aimed to develop and evaluate a risk prediction tool for estimating short-term adverse outcomes from COVID-19 infection. The outcomes include the development of a predictive algorithm, identification of risk parameters, and assessment of absolute and relative risks of severe outcomes. These findings are aligned with the project's objectives.

B) The conclusions drawn from the research appear logical and well thought out, reflecting the evidence presented in the report. The findings are supported by data derived from linked electronic health records covering a substantial population during the pandemic. The conclusions accurately summarize the outcomes of the research and their implications for risk management, clinical decision-making, and policy development.

C) The research methodology, including the use of linked electronic health records and involvement of patient advisory groups, demonstrates a robust approach to data collection and analysis. The conclusions are supported by evidence and offer valuable insights into COVID-19 risk prediction and management. Policymakers can rely on these findings to some extent.

3b. Patient and public involvement *

A) Where applicable, was there appropriate patient and public involvement in this research?
B) Did actual levels of involvement reflect those set out in the research application?
C) Could a greater emphasis on patient and public involvement have improved this study?
D) Is there evidence that findings will be shared with patients and the public (or have findings already been shared)?

(max 500 words)

A) Yes, appropriate patient and public involvement occurred in the QCOVID research. The EAVE II Patient Advisory Group (PAG) was engaged at various stages, aligning with the project plan's objectives. Despite limitations due to timing and data sensitivity, efforts were made to incorporate patient and public perspectives, particularly in validating the prediction tool.

B) The actual levels of involvement generally reflected those outlined in the research application. The engagement of the EAVE II PAG at multiple stages, as intended, was evident. However, due to project constraints, such as timing and data sensitivity, the extent of involvement may have been somewhat limited compared to initial plans.

C) While efforts were made to involve the EAVE II PAG, a greater emphasis on patient and public involvement could have improved the study. Suggestions from PAG members highlighted areas for improvement, such as enhancing the accessibility of the online tool's language for the public. Additionally, broader collaboration with other PPI groups involved in the QCOVID project and establishing feedback mechanisms could have enriched the study further.

D) There is evidence of efforts to share findings with patients and the public, although the extent of dissemination may vary. Collaboration with patient advisory groups and involvement in dissemination activities, such as infographic and publication summary production, indicate a commitment to sharing findings. However, ensuring findings are communicated in accessible formats and through diverse channels could enhance reach and impact.

3c. Intellectual property *

A) Where applicable, are you able to identify any intellectual property (IP) produced or improved on during the course of this research?
B) Is there evidence of any plans to protect or exploit any such IP?

(max 500 words)

A) Yes, intellectual property (IP) was produced and improved upon during the course of this research. The QCOVID project resulted in the development of a predictive algorithm (the risk engine) for estimating short-term adverse outcomes from COVID-19 infection. Additionally, a code library for clinical codes used to identify risk parameters was created or enhanced. Furthermore, the project involved the development of a trademark (QCOVID®) and ownership of domain names (QCOVID.org).

B) There is evidence of plans to protect and exploit the IP generated from the research. The software implementing the QCOVID risk prediction tool was registered as a medical device with the MHRA, indicating efforts to protect its intellectual property rights. Additionally, plans have been outlined to seek NIHR licensing consent for further commercialization of the IP. This suggests a strategic approach to safeguarding and capitalizing on the intellectual property developed during the research.

4. Likely impact of the research on policy and/or practice *

A) Does the research described in this report have the potential to impact on health care and/or social care and/or public health policy and service delivery?
B) Does this research add to the knowledge base on health and well-being? Does the research add value or advance what is already known in this area?
C) Have target audiences been identified and effective methods of disseminating this research proposed to maximise impact?

(max 500 words)

A) The research outlined in this report holds significant potential to influence healthcare, social care, and public health policy, and service delivery. The primary objective of the QCOVID project—to develop and evaluate a risk prediction tool for estimating short-term risks of adverse outcomes from COVID-19—directly addresses critical aspects of pandemic management. Specifically, the project's contributions to informing shielding and vaccine prioritization policies demonstrate its relevance to public health decision-making. By providing actionable insights into risk stratification and increasing efficiency of healthcare interventions, thereby positively impacting patient outcomes and resource allocation.

B) This research substantially enriches the knowledge base on health and well-being, particularly within the context of COVID-19. the project advances the understanding of the factors influencing the likelihood of adverse outcomes from the virus. The project's modelling of outcomes for both vaccinated and unvaccinated populations, including the assessment of third and fourth vaccine doses, adds value by providing nuanced insights into the effectiveness of vaccination strategies and their impact on public health.

C) The QCOVID project demonstrates a awareness of its target audiences and proposes effective dissemination methods to maximize impact. The utilization of online tools and collaborations with patient advisory groups indicate a proactive approach to engaging diverse stakeholders and facilitating knowledge translation. Through these efforts, the QCOVID project seeks to bridge the gap between research and practice in an impactful manner.

5. The value of the output relative to cost (if cost of research provided) *

A) To what extent is there evidence that the level of resources used to complete this study was appropriate and justified?
B) Has the research provided adequate outcomes for the funds spent?
C) If the researchers have suggested that any financial benefits may arise from their work, please indicate how realistic you feel these might be.

(max 500 words)

A) The resources allocated for the project seem appropriate given its complexity. Involving the EAVE II Patient Advisory Group (PAG) at different stages is commendable, despite the limitations due to timing and data sensitivity. It would be beneficial to provide more details on how resources were utilized.

B) The QCOVID Risk Prediction Tool has yielded valuable outcomes for healthcare and public health. Engaging the EAVE II PAG for feedback on usability is a positive step. However, there are concerns about the tool's language being too technical for the public. Simplifying the language would enhance its usability and accessibility.

C) It's important to realistically assess the financial benefits of the QCOVID Risk Prediction Tool. While it holds potential for healthcare decision-making, we must consider regulatory requirements and actual need. Collaborating with other groups involved in the QCOVID project and seeking feedback from researchers can provide better insights into its financial viability.

6. Suggestions for improvement to the research *

A) Do you have any thoughts on how this research might have been improved? If so, please indicate whether you see these as critical factors.

(max 300 words)

There's room for improvement in terms of user-friendliness and financial viability. I encourage further collaboration with stakeholders and ongoing refinement of the tool based on user feedback.

7. Rating Summary: *

Considering your answers to the questions above, please rate how well this final report addressed each of the criteria.

	Excellent	Good	Fair	Poor
Evidence of a clear focus on the issues specified in the research specification and the work described in the application form	☑	☐	☐	☐
Quality of the research design and work plan including methods of data collection and forms of analysis in terms of work delivered	☑	☐	☐	☐
Quality of research outcomes	☐	☑	☐	☐
The value of the output relative to cost	☐	☑	☐	☐
Likely impact of the research on policy and/or practice	☐	☑	☐	☐

Thank you

Thank you for completing this form. Please use the submit button below to confirm your responses.

Final Report Peer Review Form Policy Research Programme (PRP)

Thank you for agreeing to review this draft final report for the NIHR Policy Research Programme (PRP).

We very much appreciate you taking the time to undertake this vital part of the research process.

If you have any questions or experience any issues with submitting this form, please contact the PRP Team on 020 3692 7875

PRP Reference Number: COVID-19 Risk Prediction Tool

Project Title: COVID-19-Risk Prediction Tool

Please state your Reviewer ID *

3

Confidentiality

Once you have completed this form, your responses will be used by the Policy Research Programme (PRP) to review the project's findings and assess its outcomes.

Your completed responses are considered confidential, and are therefore exempt under the provisions of the Freedom of Information Act (section 41).

Receipt of this document from the PRP Programme, and your subsequent completed return, form a 'mutual confidentiality agreement' covering your completed responses. This information will not be released without prior consent (except to the parties named below) unless required by law. To read more about our commitment to data security and confidentiality, please consult our privacy policy.

Please treat this report and the associated application form as **confidential.**

How we will use your review

This form will be passed:

- (unattributed) to the Chief Investigator of the final report you are reviewing with the ratings summary and any conflicts of interest removed (questions 7 and 8 respectively). Please ensure

that you do not include any comments which you would not want to be seen by the Chief Investigator or which could identify you as the reviewer.
- (in its entirety) to designated individuals of the Department of Health and Social Care, who will also be made aware of your name, institution and area of expertise. These individuals will learn your name in confidence.

Using this Form

Your expertise and experience have been recognised in asking you to review for us and both the researchers and colleagues at the Department of Health and Social Care would benefit from your comments.

Please rate how the report addresses each of the criteria in the relevant sections below. The prompts are intended to help you focus on the areas addressed by the criteria, but please feel free to comment on additional aspects which you consider to be relevant.

Patient and public involvement in peer review (information for lay reviewers)

Additional information and guidance for patients, service users and carers on peer review is available from the PPIE section of the NIHR website.

Additional information for public reviewers is available - Guidance for public reviewers of research funding applications.

Conflict of Interest

We should know about any competing interests that referees may have. Are you aware of any potential competing interests that you may have? If you are in any doubt about any potential competing interest then please declare it. We will not reject your opinion simply because you declare a competing interest, but we would like to know about it, please.

Do you consider yourself to have a conflict of interest with the applicant(s) or institution? *

- ( ) Yes
- (•) No

If yes, please give details (max 100 words)

_____

Reviewer Expertise

Please indicate the nature of your expertise.

Please select *

Researcher in a broadly related field

If the options above do not adequately capture the nature of your expertise, please briefly provide details in the box below (or use it to give us more detail about your expertise if you wish). Max 20 words:

_____

Were you in involved in the peer review of the original application for funding for this piece of work?

Wherever possible, you will be sent a copy of both the original application form and the research specification that this application responded to, for reference.

*

- ( ) Yes
- (•) No

We would be grateful if you would provide us with your opinion on each of the following aspects of this study:

1. Evidence that the findings/outcomes of this research are relevant to the issues specified in the original research specification and reflect the programme of work described in the application form *

A) Does the research reflect the overall scope and aims outlined in the application form and do the findings inform the original research questions?

B) Does the report demonstrate a clear understanding of the policy context of the question(s) and are the findings/outcomes clearly linked to this?

C) Are the findings/outcomes of this research placed in context of previous relevant research in this area such that added value is immediately evident?

(max 500 words)

The research team was led by Prof Hippisley of the University of Oxford and involved researchers from many Universities and collaborators from the Department of Health and Social care, NHS Digital, NHS England, Office for national Statistics, Public Health England and the NERVTAG.
The aim was to design an adequate prediction tool for COVID mortality to identify patients at risk. The performed research was conducted as planned and reflected the original aims.
The added value was demonstarted in direct implementation of the QCOVID Risk Prediction Tool into clinical guidance and practice. The tool was updated and kept up-to-date.

2. Effectiveness of the research design and work plan (including methods of data collection and analysis) in delivering high quality, fit-for-purpose findings/outcomes for policymakers *

A) Did the research design and methodology prove appropriate to deliver the work described in the application?

B) Were the analyses conducted appropriate in terms of being able to draw robust conclusions?

C) In light of the findings/outcomes presented, are there any particular strengths and/or weaknesses of the research design or analyses chosen?

(max 800 words)

The research team led by Oxford University brought together a range of research and clinical services, national institutions for statistics and data and collaborators across the Country to quickly develop a risk stratification for COVID mortality during the pandemic. Research design and methodology were adequate with random split of the population data into derivation and validation cohorts 3:1 incorporating a significant amount of patient data to allow a broad range of factors to be analysed. The clear strength was the ability to use a national cohort with such amount of detail. The weakness was that imputation had to be used.

3. Quality of research findings/outcomes *

3a. General

A) Has this research yielded clearly defined and appropriately described findings/outcomes?
B) Are the conclusions logical and well thought out, and do they reflect the evidence presented in the report?
C) Can policymakers have confidence in the quality of the findings presented?

(max 600 words)

The QCOVID Risk Prediction Tool has very clearly achieved its aim and was useful in the identification of assumed vulnerable patients. It detected additional patients of vulnerability. The findings were confirmative and logical and have since been validated externally outside of the UK. The update kept the tool of value during the ongoing pandemic. The research plan allowed to capture a population incorporating important aspects such as deprivation and ethnicity to be investigated.

3b. Patient and public involvement *

A) Where applicable, was there appropriate patient and public involvement in this research?
B) Did actual levels of involvement reflect those set out in the research application?
C) Could a greater emphasis on patient and public involvement have improved this study?
D) Is there evidence that findings will be shared with patients and the public (or have findings already been shared)?

(max 500 words)

Confirming and reiterating the vulnerability for adverse outcome from COVID, PPIE was crucial in this research. Patients and the public were intensively involved in design, testing and distributing the research to avoid traumatisation and misunderstanding of research results. The study would not have improved by more PPIE involvement. The publicity clearly demonstrated the public involvement. The examples of feedback showed the satisfaction of PPIE contribution.

3c. Intellectual property *

A) Where applicable, are you able to identify any intellectual property (IP) produced or improved on during the course of this research?
B) Is there evidence of any plans to protect or exploit any such IP?

(max 500 words)

The IP produced is owned by University of Oxford and there is no evidence or plans to exploit the IP.

4. Likely impact of the research on policy and/or practice *

A) Does the research described in this report have the potential to impact on health care and/or social care and/or public health policy and service delivery?
B) Does this research add to the knowledge base on health and well-being? Does the research add value or advance what is already known in this area?
C) Have target audiences been identified and effective methods of disseminating this research proposed to maximise impact?

(max 500 words)

The risk prediction tool did have direct impact on health care, public health policy and service delivery. The tool was published and used to identify patients at risk for adverse outcome. The tool was updated to remain reliable despite vaccinations and viral variants and allowed the public to use a risk stratification in daily practice to identify patients suitable for antiviral medication, admission and extra vaccinations.
The research added new knowledge of pupulation health incorporating important aspects of modern society stratifying patients per risks. The results reiterated and confirmed certain assumed risk factors as well as identified new and unknown risks.
Target audiences (such as ethnic minorities with higher risk for adverse outcome) were identified and significant publicity was used to rapidly disseminate new research findings.

5. The value of the output relative to cost (if cost of research provided) *

A) To what extent is there evidence that the level of resources used to complete this study was appropriate and justified?
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(max 500 words)

Focus was on a timely result and the rapidness of the research was priority. The important consequences of highlighting vulnerbale patients and allowing the correct protection for a subpopulation resulted in reduction of death and this ensured population cost effectiveness.

6. Suggestions for improvement to the research *

A) Do you have any thoughts on how this research might have been improved? If so, please indicate whether you see these as critical factors.

(max 300 words)

In my field of expertise, I noticed the lack of completeness and correctness of diagnoses and data and subphenotyping of diseases. The granularity of data will likely improve with AI in future research projects involving prediction tools for morbidity and mortality.

7. Rating Summary: *

Considering your answers to the questions above, please rate how well this final report addressed each of the criteria.

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Quality of research outcomes	☐	☑	☐	☐
The value of the output relative to cost	☐	☑	☐	☐
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Project Title: COVID-19-Risk Prediction Tool

Please state your Reviewer ID *

PPIE 1

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Do you consider yourself to have a conflict of interest with the applicant(s) or institution? *

- ( ) Yes
- (•) No

If yes, please give details (max 100 words)

Reviewer Expertise

Please indicate the nature of your expertise.

Please select *

Member of public with a more general view

If the options above do not adequately capture the nature of your expertise, please briefly provide details in the box below (or use it to give us more detail about your expertise if you wish). Max 20 words:

Were you in involved in the peer review of the original application for funding for this piece of work?

Wherever possible, you will be sent a copy of both the original application form and the research specification that this application responded to, for reference.

*

- [ ] Yes
- [x] No

We would be grateful if you would provide us with your opinion on each of the following aspects of this study:

1. Evidence that the findings/outcomes of this research are relevant to the issues specified in the original research specification and reflect the programme of work described in the application form *

A) Does the research reflect the overall scope and aims outlined in the application form and do the findings inform the original research questions?

B) Does the report demonstrate a clear understanding of the policy context of the question(s) and are the findings/outcomes clearly linked to this?

C) Are the findings/outcomes of this research placed in context of previous relevant research in this area such that added value is immediately evident?

(max 500 words)

A) The objective of this research was to derive and evaluate a risk prediction tool to estimate short term risks of adverse outcomes from COVID-19 in adults and children which can be used to risk-stratify the general population.
This research achieved this primary objective with the development of a tool that was able to identify those at greatest risk of serious outcomes of Covid19 infection.

B) The project set out to inform Public Health interventions necessary due to the Covid 19 pandemic. The outcomes achieved this enabling the protection of vulnerable persons.

C) There was very little research that was relevant to risk stratification for a novel virus. The value of this research was immediately recognised and was used for the identification of the most vulnerable persons with respect to adverse health outcomes of infection and enabled the prioritisation of immunisation and shielding of those persons.

2. Effectiveness of the research design and work plan (including methods of data collection and analysis) in delivering high quality, fit-for-purpose findings/outcomes for policymakers *

A) Did the research design and methodology prove appropriate to deliver the work described in the application?

B) Were the analyses conducted appropriate in terms of being able to draw robust conclusions?

C) In light of the findings/outcomes presented, are there any particular strengths and/or weaknesses of the research design or analyses chosen?

(max 800 words)

A) This research used the unique NHS datasets of millions of GP health records. Complex statistical methodology was used and an algorithm derived.

B) There was considerable complexity in the statistical and computation used in this study (far beyond my understanding) but these analyses were done by experienced and collaborative teams and thus I have confidence in the approaches. The algorithm derived was robust and shown to achieve accurate prediction of death following infection with SARS-CoV-2

C) There were, inevitable, issues with the datasets that were used. The GP records were not necessarily up to date, some data would have been missing, and of course some patients would have had underlying health conditions not yet diagnosed. However it was only possible to use the data that was available and the robustness of the algorithm produced indicates that the limitations of the data were overcome by the analytical methods used.

3. Quality of research findings/outcomes *

3a. General

A) Has this research yielded clearly defined and appropriately described findings/outcomes?
B) Are the conclusions logical and well thought out, and do they reflect the evidence presented in the report?
C) Can policymakers have confidence in the quality of the findings presented?

(max 600 words)

A) The research has yielded a clear outcome in that it produced an algorithm that was used to develop PublicHealth policy with regards to the Covid19 vaccination programme.
I am not clear about the use of the algorithm by the general public.

B) The conclusions are logical, the many underlying health conditions that contribute to poor outcome following SARS-CoV2 infection have been identified.

C) Policy makers have already shown confidence in the findings.

3b. Patient and public involvement *

A) Where applicable, was there appropriate patient and public involvement in this research?
B) Did actual levels of involvement reflect those set out in the research application?
C) Could a greater emphasis on patient and public involvement have improved this study?
D) Is there evidence that findings will be shared with patients and the public (or have findings already been shared)?

(max 500 words)

A) The main objective of this research was to provide a tool for the risk stratification of the population for poor outcome to SARS-CoV2 infection. This was a tool to guide the public health policy with respect to vaccination priorities of the population. Vaccination against communicable diseases is a cornerstone of Public Health policy thus the intervention of vaccination was not open to discussion. The question was how to set up an efficient and effective programme to protect against serious illness and death from Covid19. Either the vaccination programme was informed by risk stratification taking account of co morbidities or vaccination was prioritised by some other criteria. I cannot see what PPI would have contributed to the development of the research question. PPI would have complicated the research question with time consuming and irrelevant suggestions for alternative strategies for prioritisation of vaccination.

I also cannot see what PPI could have added to the research design. GP records (of millions of patients) were used together with complex statistical and computational methods so I cannot see what alternative approaches could have been suggested by PPI.

This research was unique in that all those involved in it were, in addition to being scientists working in an area of specific expertise, were also individuals with a wider general perspective in that every member of our society stood to have a beneficial interest in the outcome of this research. I make the point that there was internal PPI within the research team. It was a large multidisciplinary group, some of whom would have had underlying health conditions and almost certainly had a diverse ethnicity.

D) This research has resulted in many scientific publications and there have been reports in the mainstream media. In addition the Covid vaccination programme has been extremely well publicised with a high degree of take up for the first phases of the programme. However the continuing success of the programme has been undermined by the somehow more effective dissemination of the conspiracy theories around the risks associated with the vaccination. And so we come back to the fuzzy line between public health interventions and personal responsibility for health. There is no obligation to have the vaccine, the decision is a personal choice, however if the results of research like this are not assimilated by the community and used to inform their personal choices then it is a failure of the dissemination process. Whether the conspiracy theories influence the decision making of the vulnerable patients with co morbidities is probably unknown and PPI has a definite and critical role in communicating the importance and value of high quality research findings. Good research is increasingly undermined by an anti science lobby.

3c. Intellectual property *

A) Where applicable, are you able to identify any intellectual property (IP) produced or improved on during the course of this research?
B) Is there evidence of any plans to protect or exploit any such IP?

(max 500 words)

The Intellectual Property has been identified and registered as a medical device.

4. Likely impact of the research on policy and/or practice *

A) Does the research described in this report have the potential to impact on health care and/or social care and/or public health policy and service delivery?
B) Does this research add to the knowledge base on health and well-being? Does the research add value or advance what is already known in this area?
C) Have target audiences been identified and effective methods of disseminating this research proposed to maximise impact?

(max 500 words)

A) The impact of the research was almost immediate since the algorithm was used to inform the prioritisation of the Covid vaccination programme.

B) The knowledge base for health and well being has increased due to this research. Public Health interventions have been informed by this research. However I do not think that this increased knowledge has been understood by the general population. The dividing line between public health interventions and personal responsibility for health is not clear. The drop off in the uptake of the Covid vaccine being a case in point. The belief in the conspiracy theories about the adverse effects of the vaccination and interference by the state has taken such prominence that the beneficial effects of the vaccination programme has been forgotten.

C) The dissemination of the results of all of the research around Covid 19 has been ineffective. The fact that most research is reported second hand (via journalists) is a real problem. A good science journalist will convey the findings well, however, how does the public know that the account they are reading has been written by a knowledgeable person? There are so many ways that information is conveyed today that it is impossible to know.
I know several people who have actively refused the booster vaccines due to their belief that there are serious side effects. These people also seem to be in denial that the vaccinations that they had might have protected them from serious illness.

5. The value of the output relative to cost (if cost of research provided) *

A) To what extent is there evidence that the level of resources used to complete this study was appropriate and justified?
B) Has the research provided adequate outcomes for the funds spent?
C) If the researchers have suggested that any financial benefits may arise from their work, please indicate how realistic you feel these might be.

(max 500 words)

A) I can't find the information regarding the value of the funding for this research. It was, however,undoubtably value for money in terms of preventing serious complications and costly hospitalisation by the timely vaccination of vulnerable patients with co morbidities

6. Suggestions for improvement to the research *

A) Do you have any thoughts on how this research might have been improved? If so, please indicate whether you see these as critical factors.

(max 300 words)

No suggestions

7. Rating Summary: *

Considering your answers to the questions above, please rate how well this final report addressed each of the criteria.

	Excellent	Good	Fair	Poor
Evidence of a clear focus on the issues specified in the research specification and the work described in the application form	☑	☐	☐	☐
Quality of the research design and work plan including methods of data collection and forms of analysis in terms of work delivered	☑	☐	☐	☐
Quality of research outcomes	☑	☐	☐	☐
The value of the output relative to cost	☑	☐	☐	☐
Likely impact of the research on policy and/or practice	☑	☐	☐	☐

Thank you

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