Modelling of hypothetical SARS-CoV-2 point-of-care tests on admission to hospital from A&E: rapid cost-effectiveness analysis

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Declared competing interests of authors: Matt Stevenson reports that he is part of a team that has received funding from Roche Diagnostics (Basel, Switzerland) in the area of biomarkers following head trauma. Michael Messenger reports that he has been a paid expert advisor to Cepheid, Inc. (Sunnyvale, CA, USA) on the development of their cancer test portfolio; he is a partner of Roche Diagnostics, with current collaborations in the field of early cancer detection and diagnosis; he is a partner of SomaLogic, Inc. (Boulder, CO, USA), with current collaborations in the field of personalised health management of pre-diabetes; that he has received in-kind co-funding from Abbott Laboratories (Chicago, IL, USA) on a kidney research project; that Siemens Healthineers (Erlangen, Germany) holds the pathology contract for Leeds Teaching Hospitals NHS Trust where he holds an honorary contract of employment; and that Avacta Life Sciences Limited (Wetherby, UK) is a spin-out company of the University of Leeds. All of these companies listed are working in the field of COVID-19 diagnostics. Furthermore, Michael Messenger is, or has been, a paid expert advisor to the European Union, including for COVID-19 therapeutics and diagnostics, a seconded scientific advisor to the UK Department of Health and Social Care to support the COVID-19 testing programme and a member of the UK Government Scientific Advisory Group for Testing.

Published March 2021
DOI: 10.3310/hta25210

Scientific summary

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Health Technology Assessment 2021; Vol. 25: No. 21
DOI: 10.3310/hta25210

NIHR Journals Library www.journalslibrary.nihr.ac.uk

Scientific summary

Background

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was identified in China in 2019, is the virus that causes coronavirus disease 2019 (COVID-19). At the time of writing (October 2020), the number of cases of COVID-19 had been approaching 38 million and more than 1 million deaths were attributable to it. SARS-CoV-2 appears to be highly transmissible and is spread primarily through secretions from the nose or mouth, which can occur when coughing, sneezing or talking.

The risks of infection in hospital are high and, if possible, cohorting patients into bays within hospital by those with SARS-CoV-2 infection and those without SARS-CoV-2 infection could reduce the number of infections in hospital. However, current laboratory-based SARS-CoV-2 tests can take a considerable time to produce a result, during which patients are often grouped by the presence or absence of clinical symptoms suggestive of COVID-19, although this can be a poor predictor of SARS-CoV-2 infection, as the symptoms of other respiratory illnesses can resemble those of COVID-19.

Currently, laboratory-based testing is relied on for detecting infections; however, considerable turnaround time is required to receive a test result. Target product profiles for point-of-care tests for SARS-CoV-2 have been released by the Medicines and Healthcare products Regulatory Agency that have a much quicker turnaround time to receive a test result than laboratory-based testing, albeit with lower diagnostic accuracy. Desirable and acceptable target product profiles were released; the clinical effectiveness and cost-effectiveness of these target product profiles are unknown.

Objective

The objective of this study is to evaluate the expected clinical effectiveness and cost-effectiveness of hypothetical point-of-care tests for SARS-CoV-2 when these are introduced into a hospital setting to test patients admitted to hospital and to evaluate different strategies related to the use of SARS-CoV-2 point-of-care tests and laboratory-based SARS-CoV-2 tests.

Methods

As the tests were hypothetical, no systematic reviews of diagnostic accuracy were undertaken. As the research was conducted to demanding deadlines, in agreement with the National Institute for Health and Care Excellence, no systematic reviews were performed. Instead, published literature was scanned and discussions with clinical experts were undertaken to identify literature sources to be used in the modelling. New evidence was being published continually and this would not have been picked up using standard systematic review techniques.

A mathematical model was constructed using an individual patient simulation methodology to allow for interactions (and the possible spread of infection) between patients, from patients to staff, from staff to patients and between staff. The model was populated from data identified in the non-systematic review. Outputs from a mathematical model included the number of infections after admission to hospital, the costs of testing patients and, where applicable, staff, and the occupancy levels of waiting bays before a decision was made to move a patient to a SARS-CoV-2-infected bay

or a non-SARS-CoV-2-infected bay. Thirty strategies using SARS-CoV-2 tests were initially modelled, with additional scenario analyses undertaken in two groups of strategies, one that incorporated the weekly testing of asymptomatic staff and one that did not. Additional strategies that evaluated the impact on model results if SARS-CoV-2 testing were not possible were run. Calibration techniques were used to ensure that the number of secondary infections associated with using the assumed strategy in place at the start of the COVID-19 pandemic was in line with published evidence. For SARS-CoV-2 point-of-care tests, the target product profiles were evaluated, as was a strategy using data from real-world point-of-care tests for SARS-CoV-2.

Owing to the large number of strategies evaluated and the potential that incremental cost-effectiveness ratios may provide misleading results when there are very small absolute differences in terms of costs and health benefits, a net monetary benefit approach was adopted, although full incremental analyses were also presented. Strategies were evaluated changing the assumed time to SARS-CoV-2 test results and laboratory-based SARS-CoV-2 tests and the assumed diagnostic accuracy.

Results

Strategies with shorter times to test results were more cost-effective, all other things being equal, as were SARS-CoV-2 tests with greater diagnostic accuracy. If a point-of-care test with the characteristics of the desirable target product profile were available, then this would have a high net monetary benefit and also would reduce the occupancy levels in waiting bays. The acceptable target product profile may be seen to be too stringent in terms of turnaround time at the expense of diagnostic accuracy, as using data from currently available SARS-CoV-2 point-of-care tests, which have a longer turnaround time but better diagnostic accuracy, consistently produced higher values of net monetary benefit. The value of testing asymptomatic staff may be dependent on the willingness-to-pay threshold per quality-adjusted life-year. As anticipated, the use of no SARS-CoV-2 testing produced the greatest number of infections but had the lowest costs associated with testing.

Discussion

There was considerable uncertainty relating to parameters within the model, although this was mitigated to some degree by the calibration undertaken. However, the results produced should be taken not as definitive, but as indicative only, with small levels of Monte Carlo sampling error remaining. It is not certain the extent to which SARS-CoV-2 point-of-care tests would reduce the test turnaround time, nor is it clear what the diagnostic accuracy of these tests would be, and thus the results remain hypothetical. It is commented that both factors are important drivers of the clinical effectiveness and cost-effectiveness of SARS-CoV-2 point-of-care tests. The relative cost of point-of-care tests to laboratory-based tests can also influence cost-effectiveness. However, a structure is in place to evaluate new SARS-CoV-2 point-of-care tests as these become available.

Conclusions

Given the heterogeneity of hospitals, no blanket solution can be provided. This report contains information that should be useful for decision-makers in assessing their own specific problem. The modelling structure developed is anticipated to be useful to assess the cost-effectiveness of SARS-CoV-2 point-of-care tests as further information on the costs, turnaround times and diagnostic accuracy of these tests becomes known.

Funding

This report was commissioned by the National Institute for Health Research (NIHR) Evidence Synthesis programme as project number 132154. This project was funded by the NIHR Health Technology Assessment programme and will be published in full in *Health Technology Assessment*; Vol. 25, No. 21. See the NIHR Journals Library website for further project information.

Health Technology Assessment

NICE TAR and DAR

ISSN 1366-5278 (Print)

ISSN 2046-4924 (Online)

Impact factor: 3.370

Health Technology Assessment is indexed in MEDLINE, CINAHL, EMBASE, the Cochrane Library and Clarivate Analytics Science Citation Index.

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This report

The research reported in this issue of the journal was commissioned and funded by the HTA programme on behalf of NICE as project number NIHR132154. The protocol was agreed in August 2020. The assessment report began editorial review in October 2020 and was accepted for publication in January 2021. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. This report has been published following a shortened production process and, therefore, did not undergo the usual number of proof stages and opportunities for correction. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

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