Cochrane Library

Cochrane Database of Systematic Reviews

Rapid, point-of-care antigen tests for diagnosis of SARS-CoV-2 infection (Review)

Dinnes J, Berhane S, Walsh J, Reidy P, Doherty A, Hillier B, Scandrett K, Hettiarachchi D, Islam F, Mathangasinghe Y, Nyaaba N, Taylor M, Weeratunga P, Wickramasinghe D, van Wyk SS, Cunningham J, Davenport C, Dittrich S, Emperador D, Hooft L, Leeflang MMG, McInnes MDF, Spijker R, Verbakel JY, Takwoingi Y, Taylor-Phillips S, Van den Bruel A, Deeks JJ, Cochrane COVID-19 Diagnostic Test Accuracy Group

Dinnes J, Berhane S, Walsh J, Reidy P, Doherty A, Hillier B, Scandrett K, Hettiarachchi D, Islam F, Mathangasinghe Y, Nyaaba N, Taylor M, Weeratunga P, Wickramasinghe D, van Wyk SS, Cunningham J, Davenport C, Dittrich S, Emperador D, Hooft L, Leeflang MMG, McInnes MDF, Spijker R, Verbakel JY, Takwoingi Y, Taylor-Phillips S, Van den Bruel A, Deeks JJ, Cochrane COVID-19 Diagnostic Test Accuracy Group.
Rapid, point-of-care antigen tests for diagnosis of SARS-CoV-2 infection.
Cochrane Database of Systematic Reviews 2025, Issue 11. Art. No.: CD013705.
DOI: 10.1002/14651858.CD013705.pub4.

www.cochranelibrary.com

WILEY

TABLE OF CONTENTS

[Diagnostic Test Accuracy Review]

Rapid, point-of-care antigen tests for diagnosis of SARS-CoV-2 infection

Jacqueline Dinnes[1,2a], Sarah Berhane[1,2], Jennifer Walsh[3], Paul Reidy[4], Aaron Doherty[3], Bethany Hillier[1,2], Katie Scandrett[1,2], Dineshani Hettiarachchi[5], Fahmida Islam[6], Yasith Mathangasinghe[7], Nicholas Nyaaba[8], Melissa Taylor[9], Praveen Weeratunga[10], Dakshitha Wickramasinghe[11], Susanna S van Wyk[12], Jane Cunningham[13], Clare Davenport[1,2], Sabine Dittrich[14], Devy Emperador[15], Lotty Hooft[16], Mariska MG Leeflang[17], Matthew DF McInnes[18], René Spijker[16,19], Jan Y Verbakel[20], Yemisi Takwoingi[1,2], Sian Taylor-Phillips[21], Ann Van den Bruel[20], Jonathan J Deeks[1,2], Cochrane COVID-19 Diagnostic Test Accuracy Group[2]

[1]Biostatistics, Evidence Synthesis, Test Evaluation and prediction Models (BESTEAM), Department of Applied Health Sciences, University of Birmingham, Birmingham, UK. [2]NIHR Birmingham Biomedical Research Centre, University Hospitals Birmingham NHS Foundation Trust and University of Birmingham, Birmingham, UK. [3]UCD National Virus Reference Laboratory, University College Dublin, Dublin, Ireland. [4]Dept of Clinical Medicine, Trinity College, Dublin, Ireland. [5]Department of Anatomy, Genetics & Biomedical Informatics, University of Colombo, Colombo, Sri Lanka. [6]Australia Regenerative Medicine Institute, Monash University, Melbourne, Australia. [7]Centre for Human Anatomy Education, Department of Anatomy and Developmental Biology, Monash University, Clayton, Australia. [8]Infectious Disease Unit, 37 Military Hospital, Cantonments, Ghana. [9]Department of Clinical Sciences, Liverpool School of Tropical Medicine, Liverpool, UK. [10]Department of Clinical Medicine, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka. [11]Department of Surgery, University of Colombo, Colombo, Sri Lanka. [12]Centre for Evidence-based Health Care, Epidemiology and Biostatistics, Department of Global Health, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa. [13]Global Malaria Programme, World Health Organization, Geneva, Switzerland. [14]Technische Hochschule Deggendorf, Rottal-Inn, Germany. [15]FIND, Geneva, Switzerland. [16]Cochrane Netherlands, Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, Netherlands. [17]Department of Clinical Epidemiology, Biostatistics and Bioinformatics, Amsterdam University Medical Centers, University of Amsterdam, Amsterdam, Netherlands. [18]Department of Radiology, University of Ottawa, Ottawa, Canada. [19]Medical Library, Amsterdam UMC, University of Amsterdam, Amsterdam Public Health, Amsterdam, Netherlands. [20]Department of Public Health and Primary Care, KU Leuven, Leuven, Belgium. [21]Division of Health Sciences, Warwick Medical School, University of Warwick, Coventry, UK

[a]ORCID iD: https://orcid.org/0000-0003-1343-7335

Contact: Jacqueline Dinnes, j.dinnes@bham.ac.uk.

Editorial group: Cochrane Central Editorial Service.
Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 11, 2025.

Citation: Dinnes J, Berhane S, Walsh J, Reidy P, Doherty A, Hillier B, Scandrett K, Hettiarachchi D, Islam F, Mathangasinghe Y, Nyaaba N, Taylor M, Weeratunga P, Wickramasinghe D, van Wyk SS, Cunningham J, Davenport C, Dittrich S, Emperador D, Hooft L, Leeflang MMG, McInnes MDF, Spijker R, Verbakel JY, Takwoingi Y, Taylor-Phillips S, Van den Bruel A, Deeks JJ, Cochrane COVID-19 Diagnostic Test Accuracy Group. Rapid, point-of-care antigen tests for diagnosis of SARS-CoV-2 infection. *Cochrane Database of Systematic Reviews* 2025, Issue 11. Art. No.: CD013705. DOI: 10.1002/14651858.CD013705.pub4.

ABSTRACT

Background

Accurate rapid diagnostic tests for SARS-CoV-2 infection could help manage the COVID-19 pandemic by potentially increasing access to testing and speed detection of infection, as well as informing clinical and public health management decisions to reduce transmission. Previous iterations of this review provided clear and conclusive evidence of superior test performance in those experiencing possible signs and symptoms of Covid-19. However, test performance in asymptomatic individuals and sensitivity by setting and indication for testing remains unclear. This is the fourth iteration of this review, first published in 2020.

Objectives

To assess the diagnostic accuracy of rapid, point-of-care antigen tests (Ag-RDTs) for diagnosis of SARS-CoV-2 infection in asymptomatic population groups.

Search methods

We searched the COVID-19 Open Access Project living evidence database from the University of Bern (which includes daily updates from MEDLINE and Embase and preprints from medRxiv and bioRxiv) on 17 February 2022. We included independent evaluations from national reference laboratories, FIND and the Diagnostics Global Health website. We did not apply language restrictions.

Selection criteria

We included test accuracy studies of any design that evaluated commercially produced, rapid antigen tests in asymptomatic people tested because of known or suspected contact with SARS-CoV-2 infection, known SARS-CoV-2 infection or known absence of infection, or those who were being screened for infection. We included evaluations of single applications of a test (one test result reported per person). Reference standards for presence or absence of infection were any laboratory-based molecular test (primarily reverse transcription polymerase chain reaction (RT-PCR)).

Data collection and analysis

We used standard screening procedures with three reviewers. Two reviewers independently carried out quality assessment (using the QUADAS-2 tool) and extracted study results. Other study characteristics were extracted by one review author and checked by a second. We present sensitivity and specificity with 95% confidence intervals (CIs) for each test, and pooled data using the bivariate model. We investigated heterogeneity by including indicator variables in the random-effects logistic regression models. We tabulated results by test manufacturer and compliance with manufacturer instructions for use and according to symptom status.

Main results

We included 146 study cohorts (described in 130 study reports). The main results relate to 164 evaluations of single test applications including 144,250 unique samples (7104 with confirmed SARS-CoV-2) obtained from asymptomatic or mainly asymptomatic populations. Studies were mainly conducted in Europe (85/146, 58%), and evaluated 41 different commercial antigen assays (test kit). Only six studies compared two or more brands of test. Nearly all studies (96%) used RT-PCR alone to define presence or absence of infection.

Risk of bias was high because of participant selection (13, 9%); interpretation of the index test (3, 2%); weaknesses in the reference standard for absence of infection (3, 2%); and participant flow and timing (46, 32%). Characteristics of participants (11, 8%) and index test delivery (117, 80%) differed from the way in which and in whom the test was intended to be used.

Estimates of sensitivity varied considerably between studies, with consistently high specificities. Average sensitivity was 55.0% (95% CI 50.9%, 59.0%) and average specificity was 99.5% (95% CI 99.5%, 99.6%) across the 147 evaluations of Ag-RDTs reporting both sensitivity and specificity (149,251 samples, 7636 cases). Average sensitivity was higher when epidemiological exposure to SARS-CoV-2 was suspected (58.6%, 95% CI 51.4% to 65.5%; 43 evaluations; 15,516 samples, 1483 cases) compared to where COVID-19 testing was reported to be widely available to anyone on presentation for testing (53.0%, 95% CI 48.4% to 57.5%; 103 evaluations; 129,032 samples, 5660 cases); however CIs overlapped, limiting the inference that can be drawn from these data. Average specificity was similarly high for both groups (99.4% and 99.6%). Sensitivity was generally lower when used in a screening context (summary values from 40.6% to 42.1% for three of four screening settings) compared to testing asymptomatic individuals at Covid-19 test centres (56.7%) or emergency departments (54.7%). We observed a decline in summary sensitivities as measures of sample viral load decreased.

Sensitivity varied between brands. When tests were used according to manufacturer instructions, average sensitivities by brand ranged from 36.3% to 78.8% in asymptomatic participants (14 assays with sufficient data for pooling). None of the assays met the WHO acceptable performance standard for sensitivity (of 80%) based on meta-analysis; however, sensitivities from individual studies (where meta-analysis was not possible) exceeded 80% for three assays. The WHO acceptable performance criterion of 97% specificity was met by all but four assays (based on individual studies or meta-analysis) when tests were used according to manufacturer instructions.

At 0.5% prevalence using summary data for asymptomatic people, where testing was widely available and where epidemiological exposure to COVID-19 was suspected, resulting PPVs would be 40% and 33%, meaning that 3 in 5 or 2 in 3 positive results will be false positives, and between 1 in 2 and 2 in 5 cases will be missed.

Authors' conclusions

Evidence for antigen testing in asymptomatic cohorts has increased considerably since the publication of the previous update of this review. Average sensitivities remain lower for testing of asymptomatic when compared to symptomatic individuals; however, there is an indication that sensitivities may be higher where epidemiological exposure to SARS-CoV-2 is suspected compared to testing any asymptomatic individual regardless of indication. Sensitivities were particularly low when antigen tests were used in screening settings. Assays from different manufacturers also vary in sensitivity, indicating the need for appropriate clinical validation of a particular antigen test in a given intended use setting prior to more widespread deployment.

Further research is needed to evaluate the effectiveness of screening programmes at reducing transmission of infection, whether mass screening or targeted approaches, including schools, healthcare setting and traveller screening.

Funding

This paper presents independent research supported by the NIHR Birmingham Biomedical Research Centre, University Hospitals Birmingham NHS Foundation Trust, and the University of Birmingham. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Registration

Protocol (2020) doi: 10.1002/14651858.CD013596

PLAIN LANGUAGE SUMMARY

How accurate are rapid antigen tests for diagnosing COVID-19?

Key messages

• Rapid antigen tests are not as accurate when used in people with no signs or symptoms of infection compared to when they are used in people who have symptoms. They perform better in this latter group who have been in contact with someone who has confirmed COVID-19; however, the evidence is not definitive.

• Accuracy of rapid antigen tests varies across different rapid antigen tests made by different manufacturers. There is a lack of evidence for many tests available on the market, and none fully meet WHO standards for diagnosing COVID-19 in asymptomatic people.

• More evidence is needed to understand if screening people without symptoms can reduce the spread of COVID-19, especially in non-healthcare settings like schools and homes.

What are rapid point-of-care antigen tests for COVID-19?

These tests are used to confirm or rule out COVID-19 infection, both for people with and without symptoms. They have several advantages:

• portable: can be used anywhere, including at home or in non-healthcare settings;

• easier to use than a laboratory-based test: minimal equipment is needed;

• less expensive: they are cheaper than standard laboratory tests;

• no need for a specialist: anyone can use them, and they do not require a specialist operator or setting; and

• quick results: you get results almost immediately.

For this review, we focused on rapid antigen tests (also called 'lateral flow tests'.) These tests detect proteins on the virus using samples from the nose or throat. They are similar to pregnancy tests and come in disposable plastic cassettes.

Why is this question important?

People without symptoms of COVID-19 need an easy and reliable way to identify whether they are infected. This helps them avoid spreading the virus to others, especially to those at high risk. COVID-19 is usually confirmed with a laboratory test called RT-PCR, which requires specialist equipment and often takes at least 24 hours to produce a result.

Rapid antigen tests make it possible for more people to get tested quickly, even if they have no symptoms. However, it is important to understand how accurate they are and how to use them correctly to avoid false results.

What did we want to find out?

We wanted to know if commercially available, rapid point-of-care antigen tests are accurate enough to reliably diagnose COVID-19 infection in people without symptoms.

What did we do?

We searched for studies that measured the accuracy of rapid antigen tests in people who had no symptoms of COVID-19. These people also had an RT-PCR test to confirm whether they were infected. The studies took place in hospitals, the community or in their own homes.

What did we find?

We reviewed 146 studies, involving 144,250 unique samples. COVID-19 was confirmed in 7104 of these samples. Studies investigated 41 different antigen tests. About 60% of the studies took place in Europe.

Main results

In people with confirmed COVID-19, antigen tests correctly identified COVID-19 infection in an average of 55% of people without symptoms. The tests were slightly more accurate for people who had been in contact with someone infected with COVID-19 (an average of 59% of people with infection were correctly identified) compared to people with no known exposure (an average of 53% of people with infection were correctly identified).

In people without COVID-19, antigen tests correctly ruled out infection in 99.5% of people.

Test accuracy varied for different brands of test. None of the tests met World Health Organization (WHO) standards for confirming or ruling out COVID-19 when tested in people without symptoms. Some tests met the WHO standard in a single study, but not when evaluated in people without symptoms.

Using summary results for people with no known contact with someone who has COVID-19 in a population of 10,000 people with no symptoms, where 50 (0.5%) of them really had COVID-19:

• 67 people would test positive for COVID-19. Of these, 40 people (60%) would not have COVID-19 (false positive result).

• 9934 people would test negative for COVID-19. Of these, 24 people (0.2%) would actually have COVID-19 (false negative result).

Using summary results for people suspected of having had contact with someone who has COVID-19, if 10,000 people without symptoms had the antigen test, and 50 (0.5%) of them really had COVID-19:

• 89 people would test positive for COVID-19. Of these, 60 people (67%) would not have COVID-19 (false positive result).

• 9911 people would test negative for COVID-19. Of these, 21 people (0.2%) would actually have COVID-19 (false negative result).

What are the limitations of the evidence?

Most studies included representative groups of people and interpreted tests in a way that was free of bias. However, studies often did not follow the manufacturer's instructions for using the test or did not test people in real-world conditions (like at the point of care).

Studies were less good at confirming that people didn't have COVID-19 infection. In over half of the studies, there was no attempt to confirm if the people who tested negative were truly free of COVID-19, for example, by considering the time since they were in contact with someone who had COVID-19 symptoms.

There were few studies directly comparing different test brands, so we cannot easily determine which one is best. It is not possible to comment on the relationship between a positive antigen test result and how infectious a person is. There is also not enough information to know whether doing repeated antigen tests lowers the risk of spreading the virus in a group of people.

How up-to-date is this review?

This review updates our previous review and includes evidence published up to 17 February 2022.

SUMMARY OF FINDINGS

Summary of findings 1. Diagnostic accuracy of point-of-care antigen tests for the diagnosis of SARS-CoV-2 infection in asymptomatic populations

Question	**What is the diagnostic accuracy of rapid point-of-care antigen tests for the diagnosis of SARS-CoV-2 infection?**			
Population	Adults or children with no signs or symptoms of COVID-19 who were undergoing testing for SARS-CoV-2 infection, including • asymptomatic contacts of confirmed COVID-19 cases • no known exposure to confirmed COVID-19 cases • community screening or other targeted screening programmes • mass screening			
Index test	Any commercially produced rapid antigen test for diagnosis of SARS-CoV-2 meeting the following criteria: • portable or mains-powered device • minimal sample preparation requirements • minimal biosafety requirements • no requirement for a temperature-controlled environment • test results available within 2 hours of sample collection			
Target condition	Detection of current SARS-CoV-2 infection			
Reference standard	For COVID-19 cases: positive molecular-based test result (PCR or TMA) For non-COVID-19 cases: negative molecular test result or pre-pandemic sources of samples			
Action	**False negative** results mean missed cases of COVID-19 infection, with either delayed or no confirmed diagnosis and increased risk of community transmission due to false sense of security **False positive** results lead to unnecessary self-isolation or quarantine, and may increase the potential for an infection to be acquired if individuals erroneously believe themselves to be immune			
Quantity of evidence (based on 146 studies reporting 164 test evaluations); • **132 (147 evaluations) reporting sensitivity and specificity** • **6 studies (11 evaluations) reporting sensitivity only** • **8 (6 evaluations) reporting specificity only**			**Total samples**	**Samples from confirmed SARS-CoV-2 cases**
	Number of studies	146	144,250	7104
	Number of test evaluations (≥ 1 per study)	164	151,503	8001

Limitations in the evidence	
Risk of bias	**Participants:** high (13) or unclear (31) risk in 44 studies (30%)
(based on 146 studies)	**Index test:** high (3) or unclear (22) risk in 25 studies (17%)
	Reference standard: high (3) or unclear (110) risk in 113 studies (77%)
	Flow and timing: high (46) or unclear (57) risk in 103 studies (71%)
Concerns about applicability	**Participants:** high (11) or unclear (16) concerns in 27 studies (18%)
(based on 146 studies)	**Index test:** high (117) or unclear (19) concerns in 136 studies (93%)
	Reference standard: unclear concerns in 79 studies (54%)

Findings from studies reporting both sensitivity and specificity

	Evaluations	**Samples (SARS-CoV-2 cases)**	**Sensitivity (95% CI)**	**Specificity (95% CI)**
Overall	**147**	**149,251 (7636)**	**55.0 (50.9, 59.0)**	**99.5 (99.5, 99.6)**
Subgroup: widely available testing*	103	129,032 (5660)	53.0 (48.4, 57.5)	99.6 (99.5, 99.6)
Subgroup: contacts (epidemiological indication for testing)*	43	15,516 (1483)	58.6 (51.4, 65.6)	99.4 (99.2, 99.5)
Subgroup: mixed, mainly asymptomatic	23	42,130 (2740)	61.5 (52.8, 69.5)	99.5 (99.5, 99.6)
Setting and indication for testing (not all represented)	**Evaluations**	**Samples (SARS-CoV-2 cases)**	**Sensitivity (95% CI)**	**Specificity (95% CI)**
COVID-19 test centre (with or without epidemiological indication for testing)	69	66,021 (4482)	56.7 (52.1, 61.2)	99.6 (99.5, 99.6)
ED/Urgent care (with no symptoms of Covid-19)	10	8184 (411)	54.7 (34.1, 73.8)	98.9 (98.6, 99.1)
Hospital in-patient (pre-procedural)	12	6245 (291)	39.8 (27.3, 53.8)	99.8 (99.6, 99.9)
Screening - schools or universities*	10	18,721 (261)	40.6 (29.7, 52.6)	99.7 (99.6, 99.8)
Screening – community wide	7	8034 (648)	42.1 (36.9, 47.5)	99.4 (99.2, 99.6)

Asymptomatic participants: average sensitivity and specificity (and 95% CIs) applied to a hypothetical cohort of 10,000 patients where 50, 100 and 200 have COVID-19 infection

	Prevalence	TP (95% CI)	FP (95% CI)	FN (95% CI)	TN (95% CI)	PPV[a]	1 – NPV[b]
Asymptomatic (widely available testing)	0.5%	27 (24, 29)	40 (40, 50)	24 (21, 26)	9,910 (9,900, 9,910)	40%	0.2%
	1%	53 (48, 58)	40 (40, 50)	47 (43, 52)	9,860 (9,851, 9,860)	57%	0.5%
	2%	106 (97, 115)	39 (39, 49)	94 (85, 103)	9,761 (9,751, 9,761)	73%	1.0%
Asymptomatic (contacts)	0.5%	29 (26, 33)	60 (50, 80)	21 (17, 24)	9890 (9870, 9900)	33%	0.2%
	1%	59 (51, 66)	59 (50, 79)	41 (34, 49)	9841 (9821, 9851)	50%	0.4%
	2%	117 (103, 131)	59 (49, 78)	83 (69, 97)	9741 (9722, 9751)	67%	0.8%
School/university screening	0.5%	20 (15, 26)	30 (20, 40)	30 (24, 35)	9920 (9910, 9930)	40%	0.3%
	1%	41 (30, 53)	30 (20, 40)	59 (47, 70)	9870 (9860, 9880)	57%	0.6%
	2%	81 (59, 105)	29 (20, 39)	119 (95, 141)	9771 (9761, 9780)	73%	1.2%

1 – NPV: 1 – negative predictive value (the percentage of people with negative results who are infected); **Ag:** antigen; **CI:** confidence interval; **Ct:** cycle threshold; **FN:** false negative; **FP:** false positive; **PPV:** positive predictive value (the percentage of people with positive results who are infected); **PCR:** reverse transcription polymerase chain reaction; **TMA:** transcription-mediated amplification; **TN:** true negative; **TP:** true positive

* denotes data used for hypothetical cohort scenarios

[a]PPV (positive predictive value) defined as the percentage of positive rapid test results that are truly positive according to the reference standard diagnosis.
[b]1-NPV (negative predictive value), where NPV is defined as the percentage of negative rapid test results that are truly negative according to the reference standard diagnosis.

BACKGROUND

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting COVID-19 pandemic presented important diagnostic evaluation challenges. These challenges have been addressed in a suite of systematic reviews addressing a range of review questions including: understanding the value of signs and symptoms in predicting possible infection [1]; assessing whether existing biochemical [2] and imaging tests [3] can identify infection or people needing critical care; and evaluating whether in vitro diagnostic tests can accurately identify and rule out current SARS-CoV-2 infection [4], and identify those with past infection [5], with or without immunity.

Point-of-care antigen-based rapid diagnostic tests (Ag-RDTs) have the potential to greatly expand access to and speed of testing. The more accurate tests may have a greater impact on public health than laboratory-based molecular methods as they are less expensive, provide results more quickly and do not require the same technical expertise and laboratory capacity. 'Rapid' tests are tests that can be undertaken locally, avoiding the need for centralised testing facilities that rarely meet the needs of patients, caregivers, health workers or society as a whole, especially in low- and middle-income countries. Test results can be returned within the same clinical encounter, thereby facilitating timely decisions concerning the need for isolation and contract tracing activities for those testing positive. The ability of negative Ag-RDTs to facilitate the return to, or continuation of, normal daily activities for those who are not experiencing symptoms of Covid-19, however, is less clear-cut. The increase in SARS-CoV-2 variants of concern (VoC) since the first published iteration of this review may also impact on the accuracy of Ag-RDTs, particularly if significant mutations in the nucleocapsid gene ('N' gene) occur [6].

This is the fourth iteration of a review summarising evidence of the accuracy of Ag-RDTs that are suitable for use at the point of care. Previous iterations of the review were published in August 2020 [7], March 2021 [8], and July 2022 [4]. The July 2022 update represented the largest and most comprehensive systematic review of Ag-RDTs published to date, and provided clear and conclusive evidence of superior test performance in individuals experiencing possible signs and symptoms of Covid-19 compared to in those who were asymptomatic [4] (see Rationale). For symptomatic people, the review demonstrated considerable variation in sensitivity by time after onset and between different brands of test. There also remained some uncertainty about the accuracy of different sample types, e.g. using nasal compared to deeper nasopharyngeal samples, and for antigen testing in children. For testing of asymptomatic individuals, the review suggested inferior test performance, and variation and uncertainty in sensitivity by setting and indication for testing (see Rationale). This targeted review update, therefore, focuses on the accuracy of Ag-RDTs in asymptomatic people, overall and in subgroups, including setting, indication for testing, age, sample type, vaccination status and SAR-CoV-2 variant.

Target condition being diagnosed

COVID-19 is a disease caused by infection with the SARS-CoV-2 virus. The target condition for this review is the identification of current SARS-CoV-2 infection, as defined by reference standard methods of diagnosis, including molecular assays such as reverse transcription polymerase chain reaction (RT-PCR), or internationally recognised clinical guidelines for diagnosis of SARS-CoV-2. In the context of test evaluation, and throughout this review, we use the term 'reference standard' to denote the best available method (test or tests) for diagnosing the target condition, as opposed to other uses of the term in diagnostic virology (such as reference methods or reference materials). For current infection, the severity of the disease is of ultimate importance for patient outcomes; however, rapid testing does not establish severity of disease, and for this review we consider the role of Ag-RDTs for detecting SARS-CoV-2 infection of any severity, distinguishing only between symptomatic and asymptomatic infection.

The global incidence of SARS-CoV-2 has been in relatively steady decline in the last few years, with weekly reported cases generally remaining below 5 million per week (with peaks in weekly reported cases of 24 million in January 2022, 7.2 million in July 2022 and 44.2 million in January 2023). Following the January 2023 peak, weekly reported cases dropped to below 5 million by February 2023, and have remained below 1 million per week since March 2023. The last recorded estimate (from the week ending March 30, 2025) was 6.7 k cases per week worldwide. (WHO 2025; https://covid19.who.int/). Over the same period, the largest reported peak in deaths from COVID-19 was in February 2022 (76,500 deaths per week), with subsequent peaks in January 2023 (32,400 per week) and February 2023 (69,700 per week). Since the end of April 2023, reported weekly deaths from COVID-19 remained below 5000 per week throughout 2023, and dropped to under 2000 per week in 2024. The last recorded estimate (from the week ending March 30, 2025) was 369 deaths recorded worldwide (WHO 2025; https://covid19.who.int/).

Very few data about international COVID-19 testing policies are available, with organisations previously reporting COVID-19 dashboards ceasing to do so from mid-2022 [9] to the end of 2023 [10, 11]. Government policies in regard to testing, self-isolation and quarantine changed over the course of the pandemic, but have seen an increasing emphasis on the use of Ag-RDTs in asymptomatic people, to prompt self-isolation to avoid infecting others, to allow 'early' release from self-isolation for those with confirmed SARS-CoV-2 infection, and daily Ag-RDTs to allow fully vaccinated contacts of confirmed cases to avoid self-isolation [12]. In the UK, current government guidance focuses on advice for those with symptoms of respiratory infection (with no expectation of testing) and what to do in the event of a positive test result (for those opting to pay for over-the-counter Ag-RDTs) but makes no specific recommendations around who should test and when [13]. In the event of further rises in infection rates or in terms of planning for future pandemics, understanding how well Ag-RDTs have performed for testing symptomatic or asymptomatic people will be key to informing future testing policies, whether to help reduce transmission of infection (via earlier self-isolation or quarantine of those who are or who may be infected), or as part of policies to minimise wider societal and economic impacts (allowing faster release from self-isolation or quarantine).

In previous review iterations, we have discussed in detail the pros and cons of different reference standards for detecting SARS-CoV-2 and for detecting people who are 'infectious' as opposed to 'infected'. The potential use and limitations of these potential reference standards are discussed in Supplementary material 6. Because of the lack of a suitable reference standard for detection of 'infectiousness', this review focuses on the target condition of

'infection' as defined by RT-PCR. Using RT-PCR status as a reference ensures that infectious people are not missed, but because RT-PCR continues to detect viral ribonucleic acid (RNA) days and weeks after the onset of infection, it will wrongly classify some infected people as infectious. While acknowledging the potential for between-study variability in viral load associated with RT-PCR cycle threshold (Ct) values in particular [14], we report results in subgroups by Ct value and continue to advise caution in interpretation. Given the current state of scientific knowledge, we do not consider it appropriate to consider these as groups that are 'infectious' or 'not infectious'.

Index test(s)

Similarly to the previous review iteration [4], this review update focuses only on Ag-RDTs, which can be used at the point of care or in non-healthcare settings such as at home (see Supplementary material 7 for the definition of 'point of care' that has been used in these reviews). In this review iteration, we only include evaluations of single applications of a test (i.e. used for diagnostic or screening purposes). Evaluations of serial testing strategies in asymptomatic populations (i.e. repeated applications of a test for earlier detection of infection) were excluded.

Ag-RDTs typically use the same upper respiratory-tract samples obtained for laboratory-based RT-PCR, that is, nasopharyngeal or combined naso- and oro-pharyngeal samples, although many companies have test kits for use with anterior nasal or nasal mid-turbinate samples, or for saliva. The majority of RDTs are lateral flow immunoassays (LFAs), which are disposable devices, usually in the form of plastic cassettes akin to an over-the-counter pregnancy test. SARS-CoV-2 antigens, most commonly the nucleoprotein, are captured by dedicated and labelled antibodies, typically colloidal gold- or fluorescent-labelled, although other assay formats are also available. The liquid sample is absorbed via passive capillary action, and the presence of the target antigen is indicated within 15 to 30 minutes either by visible lines appearing on the test strip, or through fluorescence, which can be detected using an immunofluorescence analyser. Microfluidic analytical devices are also available, typically using reader devices for test interpretation. These devices are based on the lateral flow format, using active capillary action to guide liquid samples along the test strip to the desired outlets where the chemical or biochemical reactions take place [15]. The assays are intended to detect the target antigen at lower concentrations compared to conventional LFAs [16].

Since the publication of our first review of Ag-RDTs for SARS-CoV-2 in August 2020 [7], there has been an exponential rise in the number of commercially developed RDTs. An online database of available tests for SARS-CoV-2 maintained by FIND and Johns Hopkins Centre for Health Security [17] listed 2438 tests for SARS-CoV-2 in January 2024, of which 42% (n = 1035) are Ag-RDTs (compared to 321 listed at the end of 2021).

For this targeted review update, we continue to only include evaluations of commercially produced tests. All commercially produced assays are supplied with a specific product code, product inserts or instructions for use (IFU) sheets that document the intended use of the test, sample storage and preparation and testing procedures.

Clinical pathway

Patients may be tested for SARS-CoV-2 when they present with symptoms, have had known exposure to a confirmed case, or in a screening context, with no known exposure to SARS-CoV-2. The standard approach to diagnosis of SARS-CoV-2 infection is through laboratory-based testing of swab samples taken from the upper respiratory (e.g. nasopharynx, oropharynx) or lower respiratory tract (e.g. bronchoalveolar lavage or sputum) with RT-PCR. RT-PCR is the primary method for detecting infection during the acute phase of the illness while the virus is still present, and is the only method for confirming the presence of infection in people who do not have signs or symptoms of COVID-19. For those who are symptomatic, both the WHO and the China CDC (National Health Commission of the People's Republic of China) have produced case definitions for COVID-19 that include the presence of convincing clinical evidence (some including positive serology tests) when RT-PCR is negative (Supplementary material 6).

There is no current clinical pathway for people with no signs or symptoms of Covid-19 infection. Individuals may choose to test themselves using rapid antigen tests; however, they are unlikely to be able to access RT-PCR testing for confirmation of a positive test result. In the event that an asymptomatic person has a positive antigen test result, they may choose to self-isolate to avoid transmission of infection.

Prior test(s)

Signs and symptoms are used in the initial diagnosis of suspected SARS-CoV-2 infection and to help identify those requiring tests, although a Cochrane Review of signs and symptoms found that the majority of individual signs and symptoms were insufficiently accurate to rule in or rule out disease [1]. Where people are asymptomatic but are being tested as part of screening (e.g. universal testing of students as part of a risk-reduction effort) or on the basis of epidemiological risk factors, such as exposure to someone with confirmed SARS-CoV-2 or following travel to more highly endemic countries, no prior tests will have been conducted.

Role of index test(s)

Our previous review set out a number of potential roles for Ag-RDTs in people with signs and symptoms of COVID-19, where they meet appropriate performance standards such as those set by WHO, (for example, replacing laboratory-based RT-PCR when immediate decisions about patient care must be made, or where RT-PCR cannot be delivered in a timely manner [4]).

For asymptomatic individuals, if sufficiently accurate Ag-RDTs can be identified, rapid tests may be considered for screening at-risk (exposed) populations, for example, in hospital workers or in local outbreaks, or for targeted screening at airports or for border entry, to allow entry to large public gatherings, or for screening students as a risk-reduction strategy. Because rapid antigen tests can easily be delivered at scale, they have also been deployed for mass screening purposes, as piloted in Slovakia (18), and in Liverpool, UK [19].

Accurate detection of infection in asymptomatic people could, theoretically, allow efficient contact tracing and reductions in the proportion of onward transmissions per index case, if appropriate self-isolation measures are adhered to. Similarly, negative rapid test results, for example following contact with a confirmed

case of SARS-COV-2, can facilitate the continuation of normal daily activities such as work and school, conferring important economic and educational benefits. Although evidence for testing in asymptomatic cohorts has increased, sensitivity is lower than for symptomatic individuals and questions remain about the use of antigen test-based testing strategies in different settings, including mass screening and targeted approaches, including schools, healthcare settings and traveller screening.

Alternative test(s)

Rapid point-of-care molecular assays

Molecular-based tests to detect viral RNA such as RT-PCR have historically been multi-step processes that require significant laboratory-based equipment. Automated, single-step RT-PCR methods and other nucleic acid amplification methods, such as isothermal amplification, that do not require the sophisticated thermo-cycling involved in RT-PCR are now available [20]. These technological advances have allowed molecular technologies to be developed that are suitable for use in a point-of-care context [21]; however, they still require small portable machines, are more expensive than Ag-RDTs and generally take longer to produce results, although recent advances in the turnaround time have been made. The use cases for the majority of rapid molecular assays are therefore quite different to point-of-care Ag-RDTs, and they have not been considered as a comparator index test.

Laboratory-based antigen detection tests

Antigen detection tests can also be performed in the laboratory, using automated or semi-automated enzyme immunoassays (EIA) like enzyme-linked immunosorbent assays (ELISA) or more advanced chemiluminescence immunoassays (CLIAs). Because of the limitations in detecting the SARS-CoV-2 virus in plasma or serum, antigen detection assays are primarily used with respiratory samples [22].

Rationale

It is essential to understand the clinical accuracy of tests and clinical features to identify the best way they can be used in different settings to develop effective diagnostic and management pathways for SARS-CoV-2 infection and disease. The suite of Cochrane living systematic reviews summarises evidence on the clinical accuracy of different tests and diagnostic features. Estimates of accuracy from these reviews will help inform diagnosis, screening, isolation, and patient-management decisions.

Summary of the previous versions of the review

The first iteration of this review [7] included five studies that evaluated five antigen detection tests (four commercial and one in-house). We did not find any studies at low risk of bias and had concerns about applicability of results across all studies. The average sensitivity was 56.2% (95% confidence interval (CI) 29.5 to 79.8%) and average specificity 99.5% (95% CI 98.1% to 99.9%), based on 943 samples, 596 with confirmed SARS-CoV-2. Data for individual antigen tests were limited with no more than two studies for any test.

For the subsequent update of the review ([8], published in March 2021), we restricted inclusion to evaluations of commercially produced tests. We included 48 studies that reported 58 evaluations of 16 different commercially produced RDTs. We did not judge any study as being at low risk of bias, and we had concerns about the applicability of all studies. In around a quarter of studies, the bias and applicability concerns were because of the reliance on a single RT-PCR to confirm the presence or absence of infection. Assay specificities were consistently high (overall summary specificity 99.6%, 95% CI 99.0% to 99.8%); however, estimates of sensitivity varied considerably between studies and according to test brand. In particular, we identified differences in sensitivity between symptomatic (72.0%, 95% CI 63.7% to 79.0%; 37 evaluations; 15,530 samples, 4410 cases) and asymptomatic participants (58.1%, 95% CI 40.2% to 74.1%; 12 evaluations; 1581 samples, 295 cases), and sensitivity was on average higher in the first week after symptom onset (78.3%, 95% CI 71.1% to 84.1%; 26 evaluations; 5769 samples, 2320 cases) compared to the second week of symptoms (51.0%, 95% CI 40.8% to 61.0%; 22 evaluations; 935 samples, 692 cases). Sensitivity was strongly affected by RT-PCR cycle threshold (Ct) values which were analysed above and below 25 Ct. Only the SD Biosensor STANDARD Q assay met the WHO acceptable criterion for sensitivity based on summary results across several studies.

The third review iteration, published in July 2022 [4], included 152 evaluations of 49 different commercial antigen assays, a third of which included samples from asymptomatic participants (n = 50 evaluations, 40,956 samples). Some methodological improvements were noted compared to previous iterations. We judged 37 studies as being at low risk of bias for all four domains assessed. Nearly all studies (91%) used a single RT-PCR result to define the presence or absence of infection; however, in 16% (24/152), this was the only bias identified. Just under half of studies (43%) were considered to have selected an appropriate patient group and to have conducted testing as would be expected in practice (low concerns regarding participant selection and applicability).

Average specificities remained consistently high for both symptomatic (99.1%) and asymptomatic (99.7%) participants (overall summary specificity 99.3%, 95% CI 99.2% to 99.3%). Average sensitivity was higher in symptomatic (73.0%, 95% CI 69.3% to 76.4%; 109 evaluations; 50,574 samples, 11,662 cases) compared to asymptomatic participants (54.7%, 95% CI 47.7% to 61.6%; 50 evaluations; 40,956 samples, 2641 cases), and higher in the first week after symptom onset (80.9%, 95% CI 76.9% to 84.4%; 30 evaluations, 2408 cases) than in the second week of symptoms (53.8%, 95% CI 48.0% to 59.6%; 40 evaluations, 1119 cases).

For those who were asymptomatic at the time of testing, sensitivity was higher when an epidemiological exposure to SARS-CoV-2 was suspected (64.3%, 95% CI 54.6% to 73.0%; 16 evaluations; 7677 samples, 703 cases) compared to when COVID-19 testing was reported to be widely available to anyone presenting for testing (49.6%, 95% CI 42.1% to 57.1%; 26 evaluations; 31,904 samples, 1758 cases).

We observed a steady decline in summary sensitivities as Ct values increased (i.e. as indicators of sample viral load decreased) and considerable variation in average sensitivities by brand (from 34.3% to 91.3% in symptomatic participants (20 assays with eligible data) and from 28.6% to 77.8% in asymptomatic participants (12 assays, when tests were used according to manufacturer instructions)). For symptomatic participants, summary sensitivities for seven assays met the WHO acceptable criterion for sensitivity (80% or more). For asymptomatic participants, the sensitivities of only two

assays approached but did not meet WHO acceptable performance standards (in one study each).

Changes in the evidence base since the previous version

The number of available evaluations of commercial Ag-RDTs has continued to increase for both symptomatic and asymptomatic populations. Evidence for differences in Ag-RDT test performance between symptomatic and asymptomatic participants and in several subgroups of symptomatic participants (e.g. by setting, time after symptom onset or by viral load) was comprehensively reviewed in our last review iteration such that updating these summary estimates of sensitivity and specificity with data from additional samples is unlikely to materially change the estimated values. This targeted review update, therefore, focuses on accuracy in asymptomatic populations (including consideration of the effects from reported exposure to SARS-CoV-2 and time after confirmed contact, study setting, indication for testing, age and sample type). We also report evidence for test performance in asymptomatic participants by Ag-RDT brand.

This review follows a generic protocol that covers six Cochrane COVID-19 diagnostic test accuracy (DTA) reviews [23]. The Background and Methods sections of this review, therefore, use some text that was originally published in the protocol [23], in the previous iteration of this review [7, 8], and text that overlaps some of our other reviews [1, 24].

OBJECTIVES

To assess the diagnostic accuracy of rapid point-of-care antigen tests (Ag-RDTs) for diagnosis of SARS-CoV-2 infection in asymptomatic population groups.

Secondary objectives

To explore the effect of reported epidemiological exposure to SARS-CoV-2 (testing of contacts of confirmed cases compared to widely available testing of asymptomatic individuals with no requirement to meet pre-set criteria for testing), indication for testing in different study settings, time post-contact with a confirmed case of SARS-CoV-2, viral load, age, sample type, vaccination status and prior SARS-CoV-2 infection, SARS-CoV-2 variant, assay format and test brand. Although the reference standard used can influence accuracy, we anticipated that, as in previous iterations of this review, all studies would rely on RT-PCR.

To investigate adherence to manufacturers' IFUs in sensitivity analyses.

METHODS

This review iteration addresses targeted review questions following the same methodological approach as for the previous update and described in the protocol [23], but restricting study inclusion to those that reported accuracy data separately for asymptomatic participants.

As the evidence base evolved over time, we made adjustments to our original approach with the following changes between earlier versions of the review and this fourth iteration:

- amended the primary objective to focus on accuracy in asymptomatic participants only;
- amended the secondary objectives to omit subgroup analyses by time since symptom onset (because all participants are asymptomatic); was included instead; and
- amended the secondary objectives to include subgroup analyses by time post-contact with a confirmed case of SARS-CoV-2, vaccination status and prior SARS-CoV-2 infection.

Criteria for considering studies for this review

Types of studies

We included studies of all designs that produced estimates of test accuracy or provided data from which we could compute estimates, including the following:

- Single-group studies, which recruit participants before disease status has been ascertained;
- Multi-group studies, where people with and without the target condition are recruited separately (often referred to as two-gate or diagnostic case-control studies);
- Studies restricted to participants confirmed to either have (or to have had) the target condition (to estimate sensitivity) or confirmed not to have (or have had) the target condition (to estimate specificity);
- Studies based on either participants or samples.

We excluded studies from which we could not extract data to compute either sensitivity or specificity. We also excluded small studies with fewer than 10 samples or participants. Although the size threshold of 10 is arbitrary, such small studies are likely to give unreliable estimates of sensitivity or specificity and may be biased.

We carefully considered the limitations of different study designs in the methodological quality assessment and analyses.

We included studies reported in published journal papers, as preprints, and publicly available reports from independent bodies.

Participants

We included studies that recruited people who were tested for SARS-CoV-2 infection providing separately reported results for asymptomatic participants showing no signs or symptoms of COVID-19 or if at least 75% of the study sample was reported to be asymptomatic at the time of testing. No limitations on study setting were applied.

We also included studies that recruited people known to have SARS-CoV-2 infection and known not to have SARS-CoV-2 infection (i.e. cases only or multi-group studies).

Index tests

We included studies evaluating any rapid antigen-detection test for diagnosis of SARS-CoV-2, if it met the criteria outlined in Supplementary material 7. In brief, this includes:

- Minimal equipment required;
- Minimal sample preparation and biosafety considerations;
- Results available within two hours of sample collection; and
- Commercially produced (with test name and manufacturer or distributor documented).

Any respiratory sample type was eligible. Strategies based on multiple applications of a test were excluded, as were studies that evaluated rapid molecular-based tests.

Target conditions

The target condition was current SARS-CoV-2 infection in asymptomatic or predominantly (> 75%) asymptomatic populations. We also refer to SARS-CoV-2 infection as 'COVID-19 infection', particularly in the Plain Language Summary and Summary of findings 1.

Reference standards

We originally anticipated that studies would use a range of reference standards to define both the presence and absence of SARS-CoV-2 infection; however, we have found for both previous iterations of this review that all studies used laboratory-based RT-PCR assays to confirm the presence of SARS-CoV-2 infection and almost all also used RT-PCR to confirm absence of infection (a very small proportion used pre-pandemic respiratory samples). For this iteration of the review, we therefore considered the use of any molecular assay as a suitable reference standard for confirmation of the presence or absence of SARS-CoV-2. Studies using pre-pandemic samples as non-SARS-CoV-2 cases were also eligible.

Search methods for identification of studies

The previous iteration of this review included records from electronic searches (up to 8 March 2021). Search methods for prior iterations of the review are documented in Supplementary material 1. This section documents additional searches undertaken for the current iteration of this living review up to 17 February 2022.

Electronic searches

COVID-19 Open Access Project (COAP) living evidence database from the University of Bern

We used the COVID-19 Open Access Project living evidence database from the Institute of Social and Preventive Medicine (ISPM) at the University of Bern [25]. The last feed obtained for this review was 17 February 2022. The database was constructed from daily (Monday to Friday) systematic searches of MEDLINE via PubMed, Embase via OVID, and reprints indexed in bioRxiv and medRxiv. The strategies used by ISPM for each of these electronic sources are described on the ISPM website (ispmbern.github.io/covid-19/living-review/collectingdata.html) and are tabulated in Supplementary material 1. The same search strategies as used for the last iteration of this review were still in use when the living evidence database was accessed for the current review iteration.

Since 25 May 2020, we have used artificial intelligence text analysis to classify retrieved records based on their title and abstract information, for relevant and irrelevant documents. From 1 October 2020, review-specific classifiers were developed and employed (documented in Supplementary material 1).

Searching other resources

We contacted or accessed the websites of independent research groups undertaking test evaluations (for example, UK Public Health England (PHE), the Société Française de Microbiologie (SFM), the Dutch National Institute for Public Health and the Environment (RIVM)) and studies co-ordinated by FIND (finddx.org/covid-19/sarscov2-eval), and accessed the Diagnostics Global Health listing of manufacturer-independent evaluations of antigen detecting rapid diagnostic tests (Ag-RDTs) for SARS-CoV-2 (diagnosticsglobalhealth.org). We last accessed these additional resources on 03 February 2022.

We checked the journal webpages for all included studies to identify amendments, errata, or retractions. We reviewed the amendments made and assessed any implications for the extracted data.

We appeal to researchers to supply details of additional published or unpublished studies at the following email address, which we will consider for inclusion in future updates (coviddta@contacts.bham.ac.uk).

Data collection and analysis

Selection of studies

A team of experienced systematic review authors from the University of Birmingham screened the titles and abstracts of all records retrieved from the literature searches following the application of artificial intelligence text analysis (described in Electronic searches). Two review authors independently screened studies in Covidence [26]. A third, senior review author resolved any disagreements.

We obtained the full texts for all studies flagged as potentially eligible. Two review authors independently screened the full texts; any disagreements on study inclusion were resolved through discussion with a third review author.

Up to September 2020, screening was conducted across all Cochrane COVID-19 DTA biomarker reviews (molecular, antigen or antibody tests), using tagging of records according to the review(s) for which they might be eligible. From September 2020 onwards, review-specific searches were implemented such that screening was conducted without the requirement for study tagging of different reviews.

All screening for this review was conducted by review authors who were not involved in any included studies.

For this iteration of the review, we attempted contact with the authors of 27 study reports for further information (Abusrewil 2021a [27]; Aleem 2022 [28]; Almendares 2021 [29]; Andreani 2021 [30]; Bianco 2021 [31]; Burdino 2021 [32]; Caramello 2021 [33]; Dankova 2021 [34]; Denina 2021 [35]; Dierks 2021a [36]; Frediani 2021 [37]; Hirotsu 2021 [38]; Kiro 2021a [39]; Konstantinus 2021 [40, 41]; Labhardt 2022 [42]; Landaas 2021 [43]; Leber 2021 [44]; Leiner 2021 [45]; Lopera 2022 [46]; Majam 2022 [47]; Paul 2021 [48]; Randriamahazo 2021 [49]; Robinson 2022 [50]; Singh 2021 [51]; Tande 2021 [52]; Treggiari 2022 [53]; Wagenhäuser 2021 [54]).

Data extraction and management

One review author extracted the characteristics of each study, which a second review author checked. Items that we extracted are listed in Supplementary material 8. All data extraction for this review was conducted by review authors who were not involved in any included studies.

Both review authors independently performed data extraction of 2x2 contingency tables of the number of true positives, false positives, false negatives and true negatives. They resolved

disagreements by discussion. Where possible, we extracted data separately for asymptomatic participants according to reported exposure to SARS-CoV-2, setting, time since contact (week one versus week two), viral load as defined per study (either in subgroups by Ct values or RNA copies/mL), by sample type and assay type. We also extracted all data for children (≤ 16 years or ≤ 18 years) and any within-study comparison of children versus adults, and all within-study comparisons by prior SARS-CoV-2 infection, SARS-CoV-2 vaccination, and SARS-CoV-2 variant, sample type and test operator.

We coded evaluations according to compliance with manufacturer IFUs. We based coding on three aspects of testing:

- sample type (use of any sample not explicitly mentioned in the IFU scored 'No', otherwise scored 'Yes');
- evaluations using samples that had been stored in viral transport medium (VTM) only (scored 'Yes' if specific instructions were provided and conditions were met; scored 'Unclear' if no instructions for use of samples in VTM were provided in the IFU; scored 'No' if instructions provided were not followed); and
- timing between sample collection and testing (scored 'Yes' only if all tests were carried out within the specified time period, e.g. immediate on-site testing, or for testing in laboratories if all tests reported to have been carried out within the specified time period; scored 'Unclear' if time frame for testing was not reported and 'No' if any testing was carried out beyond the maximum stipulated time frame).

Assessment of methodological quality

Two review authors independently assessed risk of bias and applicability concerns using the QUADAS-2 (Quality Assessment tool for Diagnostic Accuracy Studies) checklist tailored to this review (Supplementary material 9; [55]). The two review authors resolved any disagreements by discussion. All quality assessment of included studies was conducted by review authors who were not involved in any included studies.

Studies should prospectively recruit a representative sample of participants and clearly document eligibility criteria, including for asymptomatic people the indication for testing and time since exposure. Studies applying tests in a screening setting should document eligibility criteria for screening, particularly if a targeted approach is used and should record any previous confirmed or suspected SARS-CoV-2 infection. Studies should perform tests in their intended use setting, using appropriate samples with or without VTM and within the time period following specimen collection as indicated in the IFU document. Tests should be interpreted blinded to the final diagnosis (presence or absence of SARS-CoV-2).

The reference standard diagnosis should be blinded to the result of the rapid test, and should not incorporate the result of the rapid test. We considered the use of RT-PCR to define the presence of SARS-CoV-2 infection to have a low risk of bias because a positive result can be taken to indicate the presence of infection, even if it does not reflect the time point in the course of infection. Studies using pre-pandemic samples for estimating specificity have a low risk of bias because samples are from participants known not to have COVID-19. Those using contemporaneously collected samples have a higher risk of disease misclassification because of the inherent false negative rate of molecular tests such as RT-PCR (false negatives from RT-PCR potentially manifesting as false positive Ag-RDT results). For the absence of infection, we previously required at least two RT-PCR−negative tests to confirm the absence of infection for symptomatic participants; however, one negative RT-PCR was considered sufficient for asymptomatic participants. Studies using other types of molecular assay as a reference standard (e.g. isothermal nucleic acid test such as transcription-mediated amplification or TMA), either alone or in combination with RT-CPR for some samples were considered at unclear risk of bias. Data should be reported for all study participants, including those where the result of the rapid test was inconclusive, or participants in whom the final diagnosis of COVID-19 was uncertain. Studies should report whether results related to participants (one sample per participant), or samples (multiple samples per participant).

Statistical analysis and data synthesis

Studies sometimes referred to ‘samples’ rather than ‘patients’; however, we did not suspect that inclusion of multiple samples per study participant was a significant issue. For consistency of terminology throughout the review, we refer to results on a per-sample basis. If studies evaluated multiple tests on the same samples, we included them multiple times, i.e. results for each test were treated as separate data points so that all results from all tests evaluated in any one study could be included in the analyses. We present estimates of sensitivity and specificity per study for each test brand using paired forest plots, and summarise results using average sensitivity and specificity in tables, as appropriate. As heterogeneity is apparent in many analyses, these point estimates must be interpreted as the average of a distribution of values.

We estimated summary sensitivities and specificities with 95% confidence intervals (CI) using the bivariate model [56, 57], via the *meqrlogit* command of STATA/SE 18.0 [58]. When few studies were available, we simplified models by first assuming no correlation between sensitivity and specificity estimates and secondly, by setting near-zero variance estimates of the random effects to zero [59]. In cases where there was only one study per test, we reported individual sensitivities and specificities with 95% CI constructed using the binomial ‘exact’ (Clopper-Pearson) method [60].

Where studies presented only estimates of sensitivity or of specificity, we fitted univariate, random-effects, logistic regression models. In a number of instances where there was 100% sensitivity or specificity for all evaluations or there were few studies with highly similar sensitivity or specificity, we computed estimates and 95% CIs by summing the counts of true positives, false positives, false negatives and true negatives across 2x2 tables. These analyses are clearly marked in the tables. We present all estimates with 95% confidence intervals.

Where the same set of studies evaluated the effect of age, sample type, or test brand on the same group of patients, we made direct comparisons using bivariate models that included indicator variables. Our ability to make formal comparisons between antigen assay brands was limited by the small number of studies making direct comparisons of the same tests.

All analyses for this review are listed in Supplementary material 4. The statistical analysis for this review was conducted by a review author who was not involved in any included studies.

We created a summary of findings table for this review in accordance with the Cochrane DTA Handbook [61]. This includes results applied to three hypothetical cohorts of asymptomatic individuals.

Investigations of heterogeneity

We examined heterogeneity between studies by visually inspecting the forest plots for sensitivity and specificity. Where adequate data were available, we investigated heterogeneity related to study setting, reporting of possible epidemiological exposure (asymptomatic contacts compared to any asymptomatic individual tested), time post-contact with a confirmed case, sample type, age, viral load, test brand, and assay format by including indicator variables in the random-effects logistic regression models. We obtained absolute differences in sensitivity or specificity and corresponding P values post-estimation by using the model parameters and the *nlcom* command in STATA [58]. In instances where only one study was available per test or when tests were being directly compared following the summing of counts of the 2x2 tables, we performed test comparison using the *csi* command in STATA to calculate point estimates and confidence intervals for a risk difference.

Sensitivity analyses

We estimated overall summary sensitivities and specificities restricted to studies using single-group designs. We also estimated summary sensitivities and specificities according to test brand using only studies that were compliant to the IFU. We estimated sensitivity with and without studies that only evaluated samples with RT-PCR–confirmed SARS-CoV-2 (and thus did not estimate specificity). We performed the same analysis for specificity in studies that only evaluated RT-PCR–negative control samples.

Assessment of reporting bias

Because of uncertainty about the determinants of publication and other sources of reporting bias for diagnostic accuracy studies and the inadequacy of tests for detecting funnel plot asymmetry, we made no formal assessment of reporting bias.

Updating

We are aware of additional studies published since the electronic searches were conducted on 17 Feb 2022; however, because we have already accumulated a large body of evidence for Ag-RDT testing in both symptomatic and asymptomatic participants, this review has not been prioritised for a further update in the immediate future. Although it is likely that more recently published studies will be relevant to the use cases we have explored, we would not expect significant changes to our conclusions.

RESULTS

Results of the search

We screened 8568 unique records (published or preprints) for inclusion in this review update and for the forthcoming update of the rapid point-of-care molecular tests review. Of 409 records selected for further assessment, we identified 103 study reports that were eligible for inclusion in this review update. We also re-assessed the 130 studies that were included in the previous iteration of this review [4] against the eligibility criteria for the targeted review update. A total of 45 studies were eligible for inclusion, bringing the total number of eligible study reports to 148. See Figure 1 for the PRISMA flow diagram of search and eligibility results [62].

Figure 1. PRISMA diagram

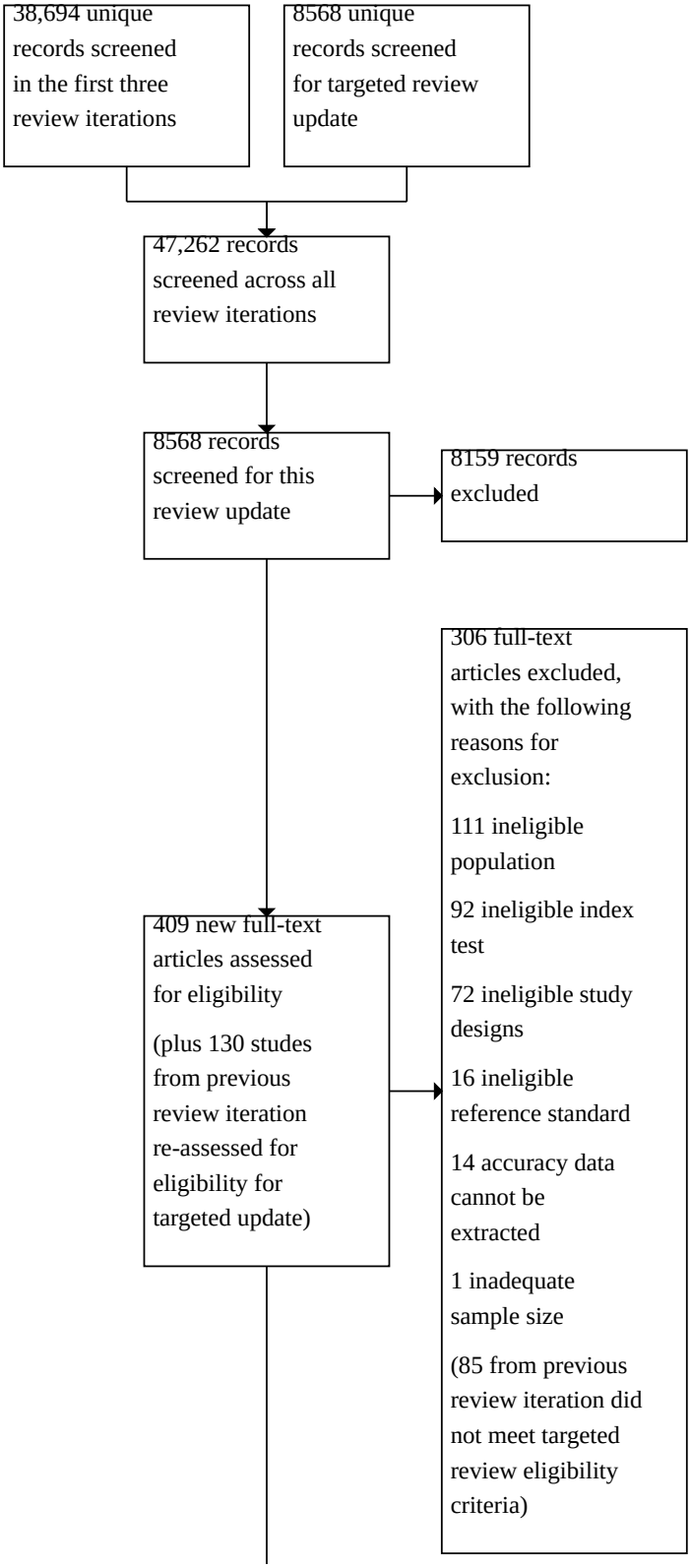
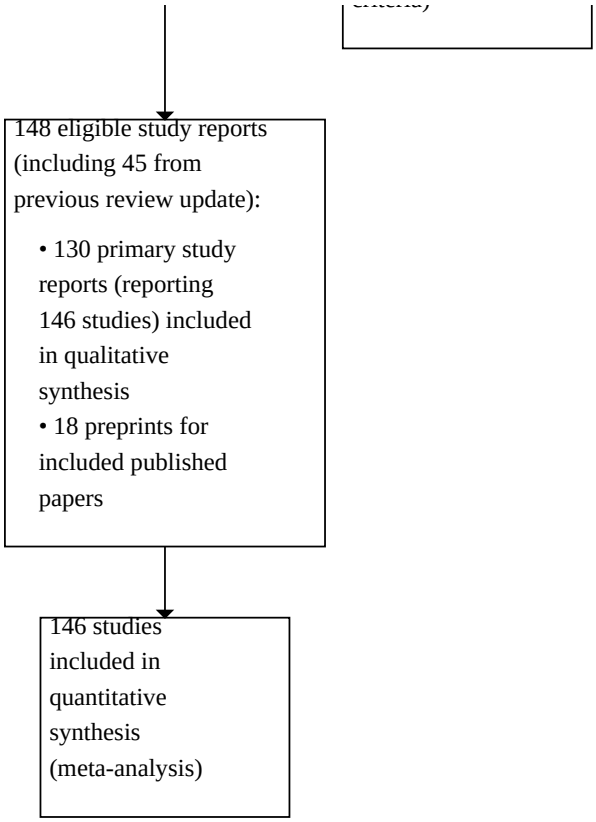


Figure 1. (Continued)



Of the 165 eligible study reports, 130 were primary study reports and 36 were secondary publications (for example, preprints associated with published papers or journal papers associated with FIND evaluation reports); one primary study report (FIND 2020b (DE) [63, 64, 65]) had two secondary publications associated with it. Of the 130 primary study reports, 119 were published journal papers, eight were available only as preprints, and three were publicly available reports either from independent reference laboratories (n = 1) or were independent evaluations co-ordinated by FIND (n = 2). We excluded 306 new publications that did not meet our inclusion criteria and 85 studies included in the previous iteration of the review. Exclusions were mainly because of ineligible populations (n = 11; either studies did not report separate data for asymptomatic participants, or did not report the percentage of symptomatic participants included); ineligible index tests (n = 92; for example, because a laboratory-based antigen detection assay was evaluated, or because the study reported repeated testing of the same individuals), or because of ineligible study designs (n = 72; for example, evaluations of analytical accuracy, or because populations were pre-selected based on prior test results). The reasons for exclusion of all 306 publications are provided in Supplementary material 3.

For this iteration of the review, we attempted contact with the authors of 27 study reports for further information (Abusrewil 2021a; Aleem 2022; Almendares 2021; Andreani 2021; Bianco 2021; Burdino 2021; Caramello 2021; Dankova 2021; Denina 2021; Dierks 2021a; Frediani 2021; Hirotsu 2021; Kiro 2021a; Konstantinus 2021; Labhardt 2022; Landaas 2021; Leber 2021; Leiner 2021; Lopera 2022; Majam 2022; Paul 2021; Randriamahazo 2021; Robinson 2022; Singh 2021; Tande 2021; Treggiari 2022; Wagenhäuser 2021). Replies were received from 10 study authors, five of which provided data which allowed their study to be included (Aleem 2022; Burdino 2021; Konstantinus 2021; Landaas 2021; Lopera 2022). Errata were identified for two included studies (Boum 2021 [66], Prince-Guerra 2021 [67]) and corrections following online publication for a further two studies (Pilarowski 2020a [68]; Pray 2021 [69]); in each case, the corrected versions had been used for data extraction for the review.

The 130 primary study reports provide data for 146 separate cohorts of participants (henceforth referred to as 'studies'), reporting 164 Ag-RDT evaluations. Please note when naming studies, we use the letters [A], [B], [C] etc. in square brackets to indicate data on different tests evaluated in the same study (evaluations) and (a), (b), (c) to indicate data from different participant cohorts from the same study report (studies). For example, the study report by Homza and colleagues corresponds to five ‘studies’ because five different Ag-RDTs were evaluated in samples from separate groups of participants (Homza 2021a(a) [70]; Homza 2021a(b) [71]; Homza 2021a(c) [72]; Homza 2021a(d) [73]; Homza 2021a(e) [74]; whereas the study report by Baro and colleagues reports five evaluations of different Ag-RDTs using samples from the same participants for all five assays (Baro 2021 [A] [75]; Baro 2021 [B] [76]; Baro 2021 [C] [77]; Baro 2021 [D] [78]; Baro 2021 [E] [79]).

Description of included studies

The 146 studies included a total of 144,250 unique samples, including 7104 samples with confirmed SARS-CoV-2 (some samples were analysed by more than one index test). Summary study characteristics are presented in Table 1 with further details of study design and index test details in Supplementary material 10 and Supplementary material 11. Full details per study are provided in Supplementary material 2.

The median sample size of the included studies is 466 (interquartile range (IQR) 145 to 874) and the median number of SARS-CoV-2-confirmed samples included is 31 (IQR 14 to 59). More than half (85/146, 58%) were conducted in Europe, 21 in Asia, 30 in North America (21%), five in South America (3%), and five in Africa.

Participant characteristics and indication for testing

Nearly two-thirds of studies reported data for any asymptomatic participant regardless of likely epidemiological exposure (94, 64%); 39 (27%) restricted to asymptomatic contacts of confirmed cases (Abdul-Mumin 2021 [80, 81]; Agullo 2021 [A] [82]; Billaud 2020 [83]; Bulilete 2021 [84, 85]; Del Vecchio 2021 [86]; Drain 2021 [87]; Drevinek 2020 [A] [88]; Farfour 2021 [89]; Fenollar 2020 [90] ; Fernandez 2022 [91]; FIND 2020b (DE) ; Garcia-Cardenas 2021 [92, 93]; Gremmels 2021 [94, 95] ; Gupta 2021 [96]; Homza 2021a(a); Homza 2021a(b); Homza 2021a(c); Homza 2021a(d); Homza 2021a(e); Homza 2021b [97]; Kanaujia 2021 [98]; Klein 2021 [A] [99]; Konstantinus 2021; Kruger 2021 [100, 101]; L'Huillier 2021 [102]; Lopera 2022; Masia 2021 [103, 104] ; Merino 2021 [105, 106]; Merino-Amador 2021 [107]; Nagura-Ikeda 2020 [108]; Schuit 2021a(a) [109, 110]; Schuit 2021a(b) [111, 112]; Shrestha 2020 [113]; Takeuchi 2021a [114, 115]; Takeuchi 2022 [A] [116, 117]; Thirion-Romero 2021 [118, 119]; Torres 2021a [120, 121]; Torres 2021b [122, 123]; Zobrist 2022 [A] [124, 125]); five (3%) reported data only for mainly asymptomatic populations (percentage symptomatic ranged from 3% to 11% (Agarwal 2021 [126]; Alghounaim 2021 [127]; Bonde 2021 [128]; Escriva 2021 [129]; Nalumansi 2021 [130])); and eight simply reported 'asymptomatic' data (Brihn 2021 [131]; Halfon 2021 [132, 133]; Jakobsen 2021b [134]; Linares 2020 [135, 136]; Parada-Ricart 2021 [137]; Schildgen 2021 [A] [138, 139]; Scohy 2020 [140]; Shah 2021 [141]).

Around half of studies (76/146, 52%) were conducted at COVID-19 test centres (65, 44%) or at emergency or urgent care departments (11, 8%) (Boyle 2021 [142]; Burdino 2021; Holzner 2021 [143]; Leli 2021 [144]; Menchinelli 2021a [145]; Merino 2021; Quentin 2022 [146]; Reichert 2021 [147]; Smith 2021b [148]; Thirion-Romero 2021; Turcato 2021 [149, 150]). Twenty-seven studies (18%) were carried out in other hospital settings, including hospital inpatients (n = 9 studies) (Aranaz-Andrez 2021 [151]; Brihn 2021; Caruana 2021a [A] [152]; Caruana 2021b [153]; Eleftheriou 2021 [154]; Kanaujia 2021; Kumar 2021b [155]; Rottenstreich 2021 [156]; Stokes 2021 [157]); outpatients (n = 2) (Thakur 2021 [158]; Zellmer 2021 [159]); both inpatients and outpatients (n = 3) (Kahn 2021 [160]; Lopera 2022; Merino-Amador 2021); or any patient, visitor, or member of staff (n = 13) (Abdul-Mumin 2021; Agarwal 2021; Bianco 2021; Bonde 2021; Del Vecchio 2021; FIND 2021 [161]; Kahn 2021; Korenkov 2021 [162]; Lopera 2022; Merino-Amador 2021; Nagura-Ikeda 2020; Nalumansi 2021; Roger 2021 [163]). A fifth of studies (30, 21%) conducted some form of screening for SARS-CoV-2, including screening students or staff of schools or universities (n = 15) (Billaud 2020; Blanchard 2021 [164]; Ferguson 2021 [165, 166]; Fernandez-Montero 2021 [167]; Ferte 2021 [168]; Ford 2021a [169]; Harris 2021 [170]; Iftner 2022(a) [171]; Iftner 2022(b) [172]; Iftner 2022(c) [173]; Iftner 2022(d) [174]; Kriemler 2021 [175]; Okoye 2021 [176]; Pray 2021; Tinker 2021 [177]); healthcare workers (n = 4) (Farfour 2021; James 2021 [178]; Osmanodja 2021 [179]; Von Ahnen 2021 [180]); or travellers (n = 2) (Cerutti 2020 [181]; Qahtani 2021 [182]); or other targeted screening (n = 5), for example, of those attending events (Di Domenico 2021 [183]; Revollo 2021 [A] [184]; Revollo 2021 [B] [185]) or during Covid-19 outbreaks as part of public health surveillance (Chiu 2021 [186, 187]; Zobrist 2022 [A]). Three studies reported community screening of the general population (defined as widely available testing with deliberate advertising to target community-wide populations) (Baro 2021 [A]; Garcia-Finana 2021 [19]; Mungomklang 2021 [188]). Four studies were conducted in nursing homes (Diez Flecha 2021 [189]; Escriva 2021; Fernandez 2022; Ifko 2021 [190]) and one in a quarantine centre as part of contact tracing (Shrestha 2020). Three studies (2%) selected samples from those submitted to laboratories for routine RT-PCR testing (Alemany 2021 [191, 192]; Halfon 2021; Scohy 2020) and in six studies samples were included from multiple settings (Boum 2021; Cubas-Atienzar 2021a [193]; Kawser 2021(a) [194, 195]; Linares 2020; Masia 2021; Muthamia 2022 [196, 197]).

Study design

More than 90% of studies (134, 92%) were intended as 'single-group' studies to estimate both sensitivity and specificity and one RCT which randomised participants with a negative Ag-RDT to either attend or not attend an indoor live event was analysed as two single-group cohorts because Ag-RDT accuracy could be calculated for both arms of the trial (Revollo 2021 [A]; Revollo 2021 [B]). Of the 136 'single-group' studies, six did not identify any confirmed SAR-CoV-2 cases, so for analysis purposes, they were treated as 'specificity only' cohorts (Iftner 2022(a); Iftner 2022(b); Iftner 2022(c); Iftner 2022(d); Qahtani 2021; Revollo 2021 [A]). Six studies (4%) used a 'two group' design with separate selection of RT-PCR−positive and RT-PCR−negative samples (Cubas-Atienzar 2021a; Fenollar 2020; Kawser 2021(a); Kawser 2021(b) [198, 199]; Nalumansi 2021; Schildgen 2021 [A]) and we could not determine study design from the information in one study report (Baro 2021 [A]). Three studies included only samples with confirmed SARS-CoV-2, thus only allowing estimation of sensitivity (Drevinek 2020 [A]; Halfon 2021; Nagura-Ikeda 2020).

Reference standard

In all studies, the target condition was the presence of SARS-CoV-2 infection. Almost all studies defined the presence or absence of SARS-CoV-2 infection based on RT-PCR alone, either a single (138; 95%) or double positive RT-PCR (2, 1.4%). Six studies employed transcription-mediated amplification (TMA), either as the sole reference standard (1, 0.7%; Roger 2021), as an alternative to RT-PCR for some samples (2, 1.4; Kahn 2021; Stokes 2021) or as a first-line test with RT-PCR confirmation of TMA positive samples (3, 2%; Revollo 2021 [A]; Revollo 2021 [B]; Venekamp 2022(d) [200]). One hundred and forty-one (96.6%) studies required a single negative result to confirm absence of infection (whether RT-PCR or TMA), and one used two RT-PCR assays in all participants (double negative PCR indicating absence of infection; Kurihara 2021 [201, 202]). The remaining four studies included only RT-PCR positive cases. Schuit 2021a(a) used routine national testing data to determine whether any RT-PCR-ve had a subsequent +ve RT-PCR or Ag-RDT result within 10 days. Fifty-two (36%) studies

explicitly reported the Ct threshold used to indicate a positive result (range < 32 Ct (Thakur 2021) to < 45 Ct (Ferte 2021)) (Abdul-Mumin 2021; Aleem 2022; Allan-Blitz 2021 [203]; Aranaz-Andrez 2021; Brihn 2021; Di Domenico 2021; Drevinek 2020 [A]; Escriva 2021; Ferguson 2021; Ferte 2021; Fitoussi 2021 [204]; Ford 2021a; Ford 2021b [205]; Garcia-Cardenas 2021; Harris 2021; Holzner 2021; Homza 2021a(a); Homza 2021a(b); Homza 2021a(c); Homza 2021a(d); Homza 2021a(e); Homza 2021b; Jakobsen 2021a [206, 207]; Jakobsen 2021b; James 2021; Jegerlehner 2021 [208]; Kawser 2021(a); Kawser 2021(b); King 2021 [209]; Kumar 2021b; Leli 2021; Mungomklang 2021; Muthamia 2022; Nalumansi 2021; Okoye 2021; Pena 2021 [210]; Pollock 2021a [211]; Pollock 2021b [212]; Qahtani 2021; Salcedo 2021 [213, 214]; Schrom 2022 [215]; Schuit 2021b(a) [216]; Schuit 2021b(b) [217]; Scohy 2020; Shah 2021; Sood 2021 [218]; Suliman 2021 [219, 220]; Takeuchi 2022 [A]; Thakur 2021; Tinker 2021; Von Ahnen 2021; Wertenauer 2021 [A] [221, 222]).

One hundred and twenty-eight studies (87.7%) obtained paired swabs for index and reference standard (82 from the same sample type as the index test and 46 from alternative sample types), 16 (11%) used the same swab for index and reference standard and, in two studies, it was not possible to determine this information from the study report.

Index tests

The 146 studies in asymptomatic populations reported a total of 164 separate test evaluations. One hundred and forty studies (96%) evaluated a single Ag-RDT assay; three studies compared two assays (Drevinek 2020 [A]; Wertenauer 2021 [A]; Zobrist 2022 [A]) and one study each compared three (Schildgen 2021 [A]), four (Caruana 2021a [A]) and five (Baro 2021 [A]) assays using the same sample type. Six of the 146 studies compared results from different sample sites using the same Ag-RDT (Agullo 2021 [A]; Goodall 2022(a) [A] [223, 224]; Goodall 2022(b) [A] [225, 226]; Klein 2021 [A]; Takeuchi 2022 [A]; Zobrist 2022 [A]). The denominator for the index test details in Table 1 is the 164 evaluations by assay or sample type.

The 164 test evaluations included 121 (74%) assessments of colloidal gold-based immunoassays (CGIAs); 11 (7%) fluorescent immunoassays (FIAs), five alkaline phosphatase-labelled antibodies (ALP) (n = 1) or latex-conjugated LFAs (n = 4), and 19 (12%) microfluidic FIAs. Full details for all 41 assays evaluated are provided in Supplementary material 12.

Multiple combinations of sample and swab (direct or use of transport medium) were reported across the test evaluations. More than half of evaluations (90, 55%) obtained nasopharyngeal samples in all participants, either alone (n = 84, 51%) or in combination with oropharyngeal samples (6, 4%) (Goodall 2022(b) [B] [227, 228]; Korenkov 2021; Kumar 2021b; Landaas 2021; Wertenauer 2021 [A], Wertenauer 2021 [B] [229, 230]). A further three evaluations (2%) used either nasopharyngeal or oropharyngeal samples (FIND 2020b (DE); Kahn 2021; Zellmer 2021). Nasal samples were used in 51 (35%) evaluations: 32 (20%) used anterior nasal samples (Allan-Blitz 2021; Almendares 2021; Brihn 2021; Chiu 2021; Drain 2021; Ford 2021b; Goodall 2022(a) [A]; Goodall 2022(b) [A]; Harris 2021; Jakobsen 2021b; James 2021; Kawser 2021(a); Leli 2021; Muthamia 2022; Osmanodja 2021; Pilarowski 2020a; Pilarowski 2021 [231, 232]; Pollock 2021a; Pollock 2021b; Prince-Guerra 2021; Schrom 2022; Schuit 2021b(b); Shah 2021; Siddiqui 2021 [233]; Sood 2021; Stokes 2021; Suliman 2021; Sun 2022 [234, 235]; Takeuchi 2022 [B] [236, 237]; Tinker 2021; Zobrist 2022 [A]; Zobrist 2022 [C] [238, 239]); seven (4%) used nasal mid-turbinate samples (Alemany 2021; Ford 2021a; Klein 2021 [A]; Kruger 2021; Okoye 2021 ; Pray 2021; Tonen-Wolyec 2021 [240]); and in 12 (7%) the type of nasal sample was not reported (Agullo 2021 [A]; Bianco 2021; Blanchard 2021; Burdino 2021; Fernandez 2022; Iftner 2022(a); Iftner 2022(b); Iftner 2022(c); Iftner 2022(d); Nalumansi 2021; Parada-Ricart 2021; Salcedo 2021). Six evaluations (4%) used combined nasal and oropharyngeal samples (Boyle 2021; Garcia-Finana 2021; Schuit 2021a(a); Venekamp 2022(a) [241]; Venekamp 2022(c) [242]; Venekamp 2022(e) [243]) and four used saliva samples (Agullo 2021 [B] [244]; Nagura-Ikeda 2020; Schuit 2021b(a); Zobrist 2022 [B] [245, 246]). Other sample types were used in the remaining nine evaluations (5%), including oropharyngeal alone (n = 2) (Bonde 2021; Goodall 2022(a) [B] [247, 248]); bronchoalveolar lavage or throat wash (n = 3) (Schildgen 2021 [A]; Schildgen 2021 [B] [249]; Schildgen 2021 [C] [250]); nasopharyngeal aspirate (n = 1) (Quentin 2022); buccal swabs (n = 1) (Kriemler 2021); multiple sample types (n = 1) (Garcia-Cardenas 2021); or not specified sample type (n = 1) (Del Vecchio 2021).

More than 80% of test evaluations used direct swab testing (137/164, 84%), 16 (10%) tested samples in VTM or saline, one study used either direct swab testing or VTM, and 10 studies (6%), did not provide details.

Samples were collected by healthcare workers in 63/164 (38%) evaluations (Abdul-Mumin 2021; Agullo 2021 [A]; Alghounaim 2021; Almendares 2021; Aranaz-Andrez 2021; ; Baro 2021 [B]; Baro 2021 [C]; Baro 2021 [D]; Baro 2021 [E]; Boyle 2021; Brihn 2021; Bulilete 2021; Caruana 2021b; Chiu 2021; Escriva 2021; Farfour 2021; Fernandez-Montero 2021; FIND 2021; Fitoussi 2021; Ford 2021a; Holzner 2021; Homza 2021a(a); Homza 2021a(b); Homza 2021a(c); Homza 2021a(d); Homza 2021a(e); Homza 2021b; Ifko 2021; Jegerlehner 2021; Kanaujia 2021; Klein 2021 [B] [251]; Konstantinus 2021; Le Goff 2021 [252, 253]; Leli 2021; L'Huillier 2021; Linares 2020; Masia 2021; Menchinelli 2021a; Merino-Amador 2021; Pena 2021; Prince-Guerra 2021; Quentin 2022; Reichert 2021; Revollo 2021 [A]; Revollo 2021 [B]; Roger 2021; Rottenstreich 2021; Siddiqui 2021; Smith 2021b; Sun 2022; Takeuchi 2022 [A]; Takeuchi 2022 [B]; Thirion-Romero 2021; Torres 2021a; Torres 2021b; Turcato 2021; Venekamp 2022(a); Venekamp 2022(b) [254]; Venekamp 2022(c); Venekamp 2022(d); Venekamp 2022(e); Von Ahnen 2021); self-collected in 24 (15%) (Ferguson 2021 ; Ford 2021b ; Garcia-Finana 2021 ; Goodall 2022(a) [A] ; Goodall 2022(a) [B] ; Goodall 2022(b) [A] ; Goodall 2022(b) [B] ; Harris 2021 ; Iftner 2022(a) ; Iftner 2022(b) ; Iftner 2022(c) ; Iftner 2022(d) ; Klein 2021 [A] ; Kruger 2021 ; Nagura-Ikeda 2020 ; Okoye 2021 ; Osmanodja 2021 ; Schuit 2021b(a) ; Schuit 2021b(b) ; Shah 2021 ; Tinker 2021 ; Tonen-Wolyec 2021); collected by trained 'personnel' or non-healthcare workers in 23 (14%) (Billaud 2020; Di Domenico 2021; Ferte 2021; FIND 2020b (DE); Jakobsen 2021a; Jakobsen 2021b; Kahn 2021; Kawser 2021(a); Kawser 2021(b); King 2021; Korenkov 2021; Kriemler 2021; Landaas 2021; Pollock 2021a; Pollock 2021b; Schuit 2021a(a); Schuit 2021a(b); Sood 2021; Suliman 2021; Thakur 2021; Wertenauer 2021 [A]; Wertenauer 2021 [B]; Zellmer 2021); and by laboratory scientists in five test evaluations (Aleem 2022; Nalumansi 2021; Pilarowski 2020a; Pilarowski 2021; Schrom 2022). In 46 (28%), the sample collection was not described (Agarwal 2021; Alemany 2021; Bianco 2021; Bonde 2021; Boum 2021; Burdino 2021; Caruana 2021a [A]; Caruana 2021a [B] [255]; Caruana 2021a [C] [256]; Caruana 2021a [D] [257]; Cerutti 2020; Del Vecchio 2021; Diez Flecha 2021; Drain 2021; Drevinek 2020 [A]; Drevinek

2020 [B] [258]; Eleftheriou 2021; Fenollar 2020; Fernandez 2022; Garcia-Cardenas 2021; Gremmels 2021; Gupta 2021; Halfon 2021; James 2021; Kiyasu 2021 [259, 260]; Kumar 2021b; Kurihara 2021; Lopera 2022; Merino 2021; Mungomklang 2021; Muthamia 2022; Pandey 2021 [261]; Parada-Ricart 2021; Qahtani 2021; Salcedo 2021; Schildgen 2021 [A]; Schildgen 2021 [B]; Schildgen 2021 [C]; Scohy 2020; Shrestha 2020; Stokes 2021; Suzuki 2021 [262, 263]; Takeuchi 2021a; Zobrist 2022 [A]; Zobrist 2022 [B] ; Zobrist 2022 [C]); and in three, samples were collected by individuals with different levels of expertise (Allan-Blitz 2021; Cubas-Atienzar 2021a; Pray 2021). Samples were tested and interpreted by healthcare workers in 45 (27%) evaluations, by laboratory scientists in 25 (15%), by trained 'personnel' or non-healthcare workers in 28 (17%), and in seven (4%) evaluations, samples were self-tested. In 59 (36%) evaluations, the expertise of the person interpreting the test was not reported, although for 41 of these evaluations, test interpretation was judged to have been conducted on-site after sample collection.

We considered 117 of 164 evaluations (71%) to be compliant with manufacturer IFUs in terms of sample type, use of VTM, and time interval between collection and testing; 33 evaluations (20%) were judged not compliant with IFUs; and in 14, insufficient information was provided to allow IFU compliance to be judged.

Methodological quality of included studies

We report the overall methodological quality assessed using the QUADAS-2 tool [55] for all studies (n = 146) in Figure 2, and study level data in Figure 3. See Supplementary material 13 for a plot of study-level ratings by quality domain. We explain how we reached these judgements in Supplementary material 9.

Figure 2. Risk of bias and applicability concerns graph: review authors' judgements about each domain presented as percentages across included studies

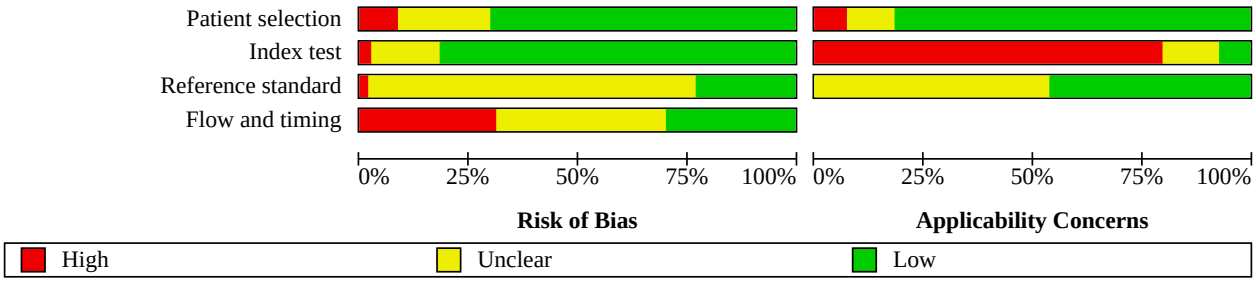


Figure 3. Risk of bias and applicability concerns summary graph: review authors' judgements about each domain for each included study

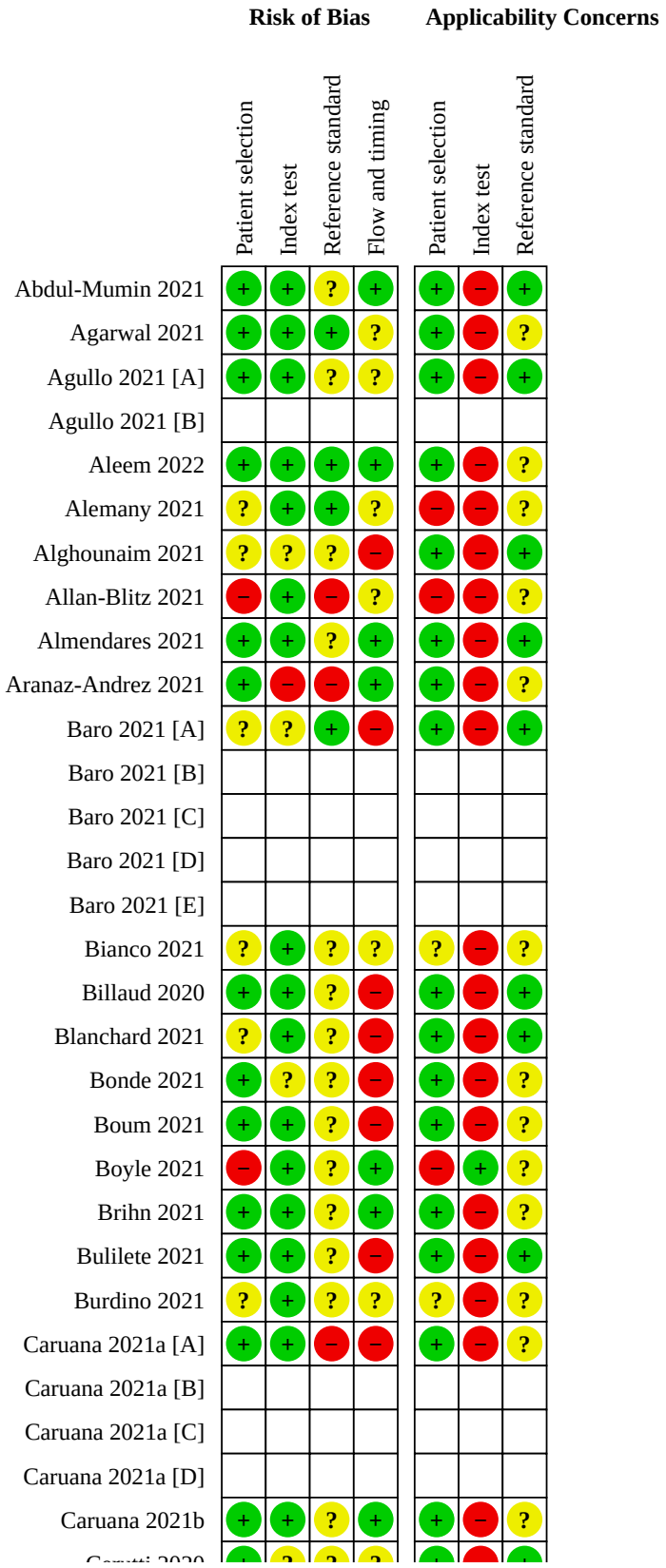


Figure 3. (Continued)

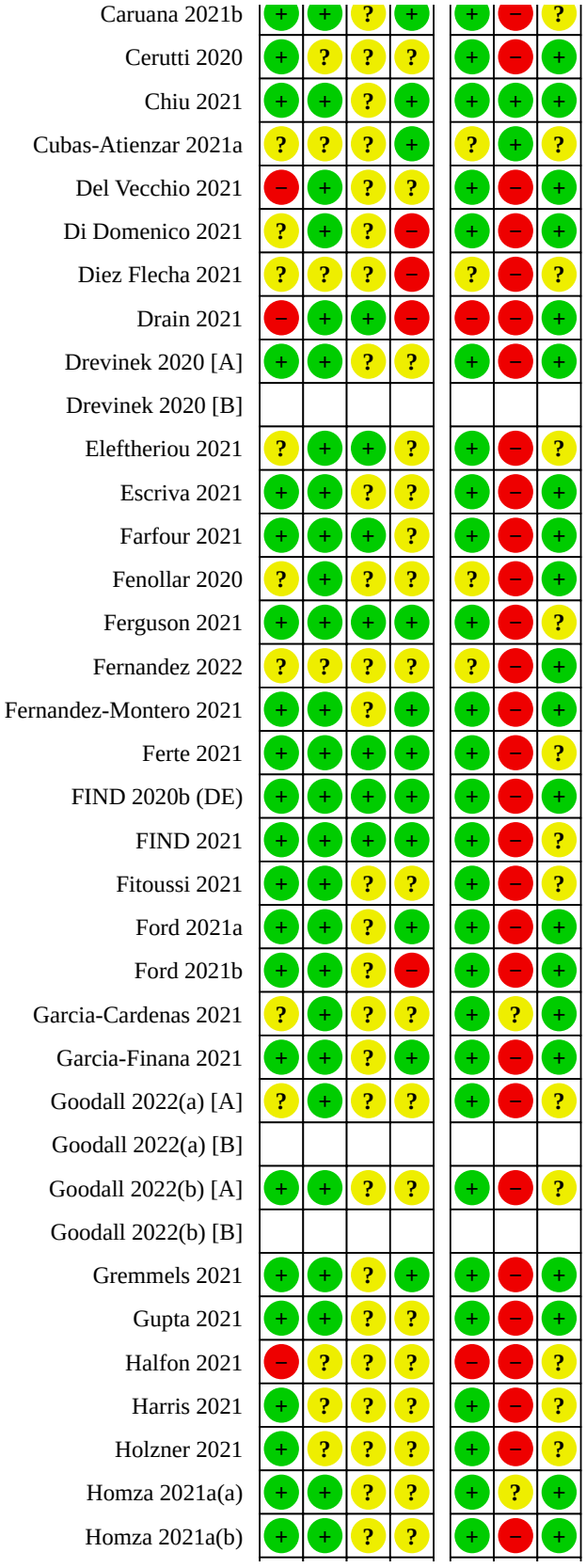


Figure 3. (Continued)

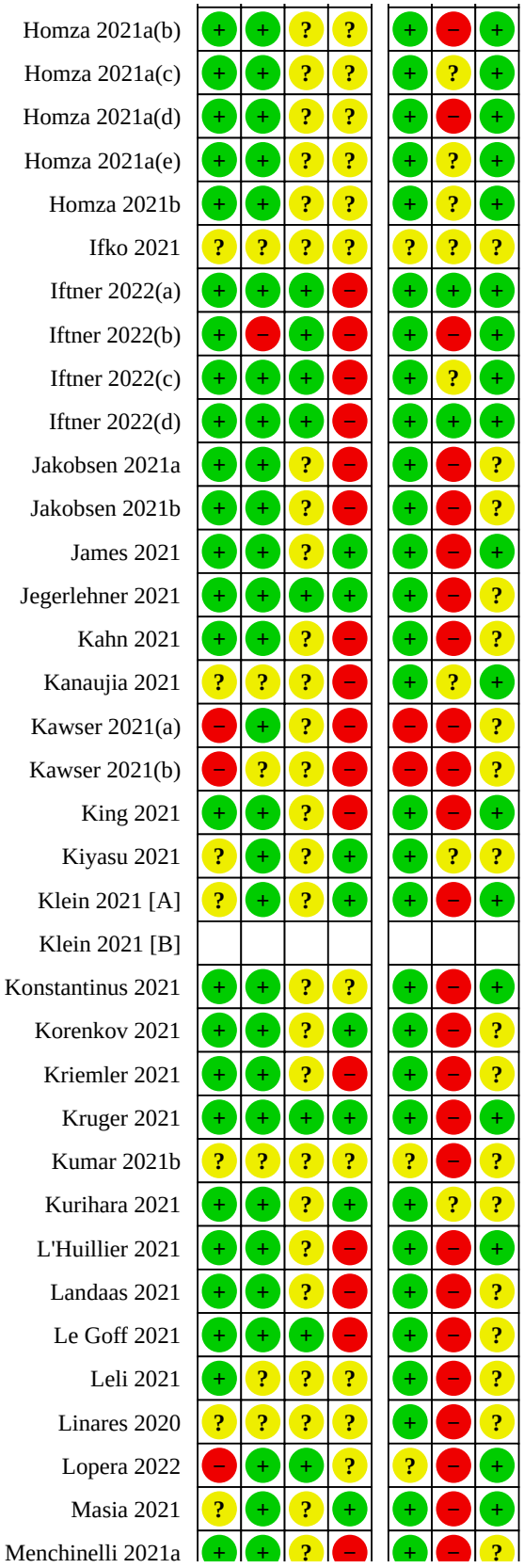


Figure 3. (Continued)

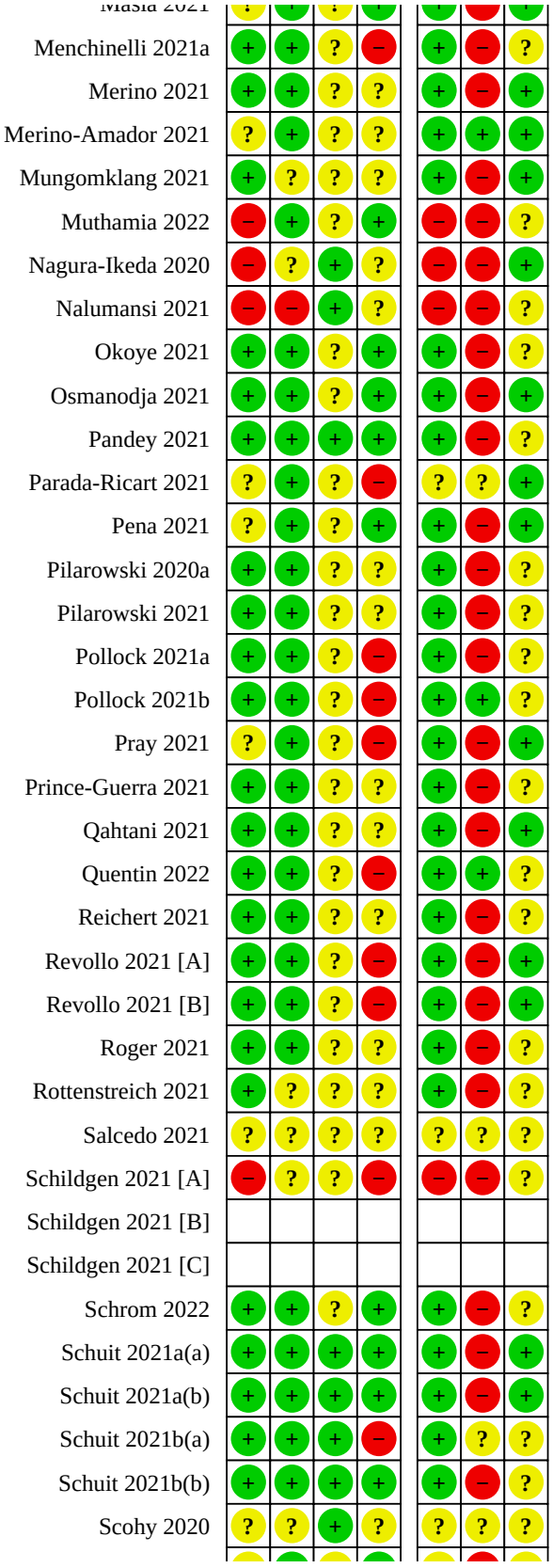
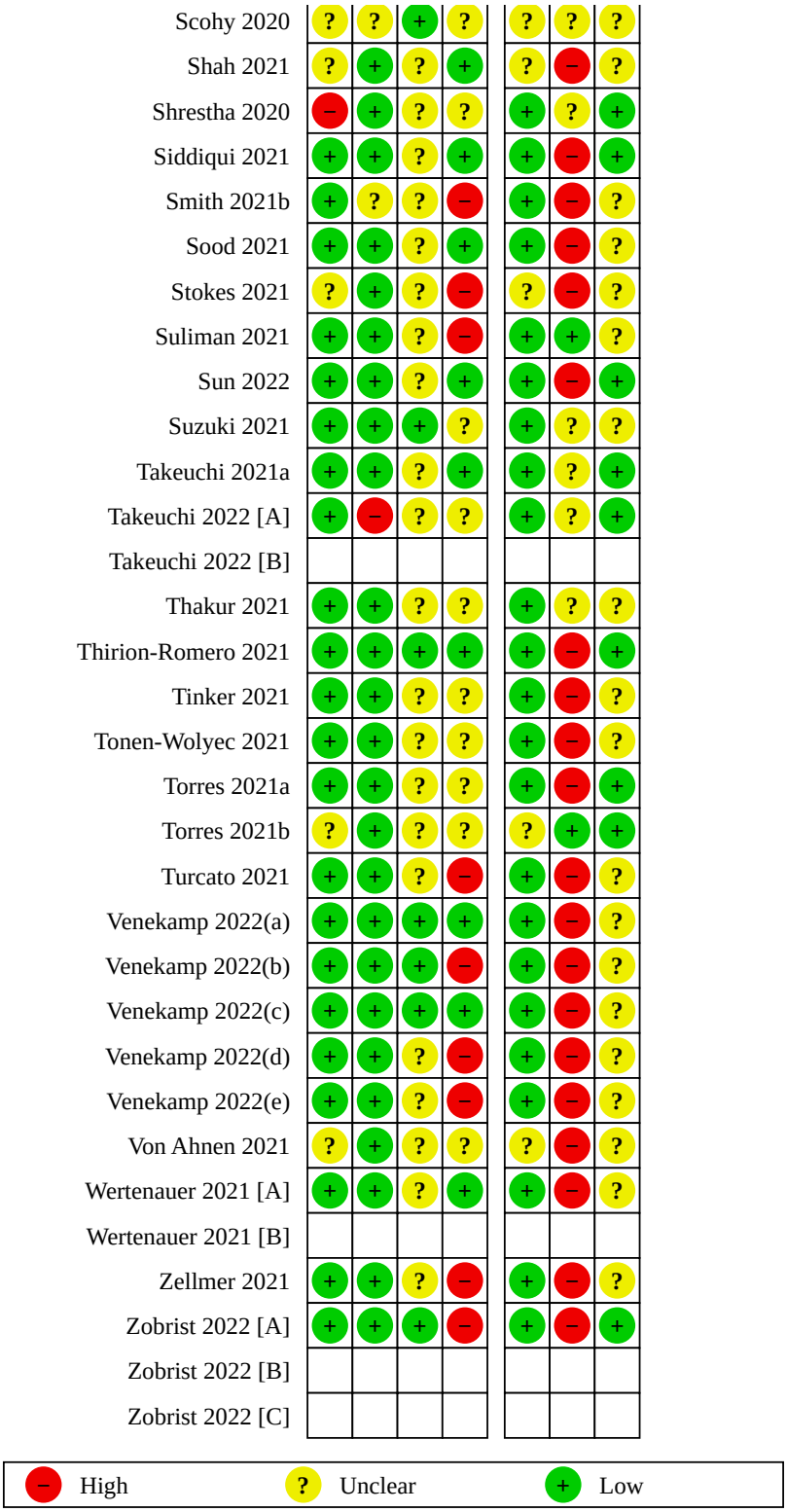


Figure 3. (Continued)



We considered whether the findings of individual studies were at risk of bias, and whether there were concerns that results might not apply to standard use of the tests. We judged 14 studies to be at low risk of bias for all QUADAS-2 domains assessed (Aleem 2022; Ferguson 2021; Ferte 2021; FIND 2020b (DE); FIND 2021; Jegerlehner 2021; Kruger 2021; Pandey 2021; Schuit 2021a(a); ;

Schuit 2021a(b); Schuit 2021b(b); Thirion-Romero 2021; Venekamp 2022(a); Venekamp 2022(c)), four of which also had low concerns about applicability in all domains (FIND 2020b (DE); Kruger 2021; Schuit 2021a(a); Schuit 2021a(b); Thirion-Romero 2021). In a further 20 studies, the only concern regarding risk of bias was lack of blinding of the reference standard to the result of the index test.

Participant selection

We judged 102 studies (70%) to be at low risk of bias for participant sampling. High risk of bias was present in 13 (9%) (because of reporting of non-consecutive sampling (3), deliberate sampling of participants based on the reference standard result (4), or both reasons (6)). In 31 studies (21%), the risk of bias was unclear because of poor reporting of recruitment procedures or inclusion criteria (Figure 2).

We considered the majority (119, 82%) of studies to have selected an appropriate patient group, we had high concerns about the applicability of the selected participants in 11 studies, and had insufficient information to make a judgement for 16 (11%) studies.

Index tests

Eighty-two percent of studies had a low risk of bias for the index test (119/146). Four studies were judged to be at high risk of bias for not implementing blinding of index test interpretation to the reference standard result, and in the remaining 23 (16%) studies, the risk of bias was unclear.

Just over three-quarters of studies (117/146; 80%) were considered to have high concern regarding applicability, either because at least one test evaluated did not comply with manufacturer IFUs in terms of sample type, use of VTM, or sample storage conditions (13/117), or because the test was specifically intended for use in people with symptoms of COVID-19 (104/117). For 19 studies, applicability was unclear because the intended population was not specified on the IFU (12/19) or the IFU could not be obtained for the test (7/19). We had no concerns as regards the remaining 10 studies.

Reference standards

Overall, 33 (23%) studies were at low risk of bias for the reference standard (Figure 2) and in three (2%), high risk of bias was present because the reference standard was not blinded to the index test result. The risk of bias was unclear for 110 studies (75%); in 103, because reference standard interpretation was not reported as interpreted blinded to the index test result, in two because TMA was used as part of the reference standard, and in five because of both lack of blinding and use of TMA.

None of the studies were judged as having high concerns about the applicability of the reference standard. We considered 79 (54%) studies to have unclear concerns because they did not attempt to identify whether SARS-CoV-2 cases detected were likely to be current (for example by considering contact with confirmed cases or time since likely exposure). In 67 (46%) studies, concerns about applicability were low because they included asymptomatic individuals attending community or targeted screening (17) or because results were presented by time after likely exposure to SARS-CoV-2 (50).

Flow and timing

We judged 43 (29%) studies to have low risk of bias for participant flow and timing (Figure 2). Forty-six (32%) were at high risk of bias (some for more than one reason) because of missing samples or exclusion of samples following invalid index test results (n = 38), because of reported delays between 'paired' swabs of up to three days (n = 6), or because different reference standards were used (n = 8). We judged the risk of bias to be unclear for 57 (39%) studies (some for more than one reason), in most (n = 48) because of lack of clarity about participant inclusion and exclusion from analyses with no missing data or indeterminate test results reported, whilst for five studies, the timing of index and reference sample collection was unclear and for six studies, there was a lack of details about reference standards used (n = 6) (numbers not exclusive).

Findings

Of the 146 included studies, 135 evaluated a single Ag-RDT and sample type and 11 compared the accuracy of two or more different Ag-RDTs (n = 6) or different sample types (n = 6) (one study reported a comparison of Ag-RDTs and a comparison of sample types) (Table 1). To include all results from all tests in these analyses, we have treated results from all evaluations as separate data points, such that data are available on 164 evaluations by assay or sample type.

The results tables identify where estimates are based on multiple assessments of the same samples by including both the number of test evaluations and the number of studies. Although four evaluations came from studies designed as 'cases only' studies (i.e. reporting only sensitivity estimates) (Drevinek 2020 [A]; Drevinek 2020 [B]; Halfon 2021; Nagura-Ikeda 2020), a further seven only reported sensitivity data for asymptomatic cases (i.e. symptom status was not available for asymptomatic cases who were RT-PCR negative for SARS-CoV-2 (Boum 2021; Burdino 2021; Del Vecchio 2021; Ferte 2021; Zobrist 2022 [A]; Zobrist 2022 [B]; Zobrist 2022 [C])). Six evaluations did not identify any RT-PCR positive cases of SARS-CoV-2, therefore reporting 'specificity only' data (Iftner 2022(a); Iftner 2022(b); Iftner 2022(c); Iftner 2022(d); Qahtani 2021; Revollo 2021 [A]).

Summary results and heterogeneity investigations were therefore calculated for all evaluations providing both sensitivity and specificity data (n = 147) (Table 2) and then including data from sensitivity-only evaluations (n = 158) or specificity-only evaluations (n = 153) (Supplementary material 14). The primary analysis was also conducted with and without the five studies that only reported data for 'mainly (> 75%) asymptomatic' populations. The numbers of true positives, false positives, and total samples with and without confirmed SARS-CoV-2 infection are based on test result counts.

Forest plots of study data for the primary analysis (including all evaluations by test brand but excluding comparisons by sample type or test interpretation) are shown in Figure 4. Forest plots of data for subgroup analyses by reported exposure to SARS-CoV-2 are in Figure 5 and Figure 6. Forest plots of data for all other subgroup analyses are included in Supplementary material 15 (time after contact (Figure 7), subgroups by Ct values (Figure 8), children compared to adults (Figure 9), according to sample type in Figure 10 and Figure 11).

Figure 4. Forest plot of data contributing to overall analysis, sorted by study setting (n = 147 evaluations; 142 in asymptomatic and 5 in mainly asymptomatic cohorts) DE: Germany; ED: emergency department; HCW: healthcare worker

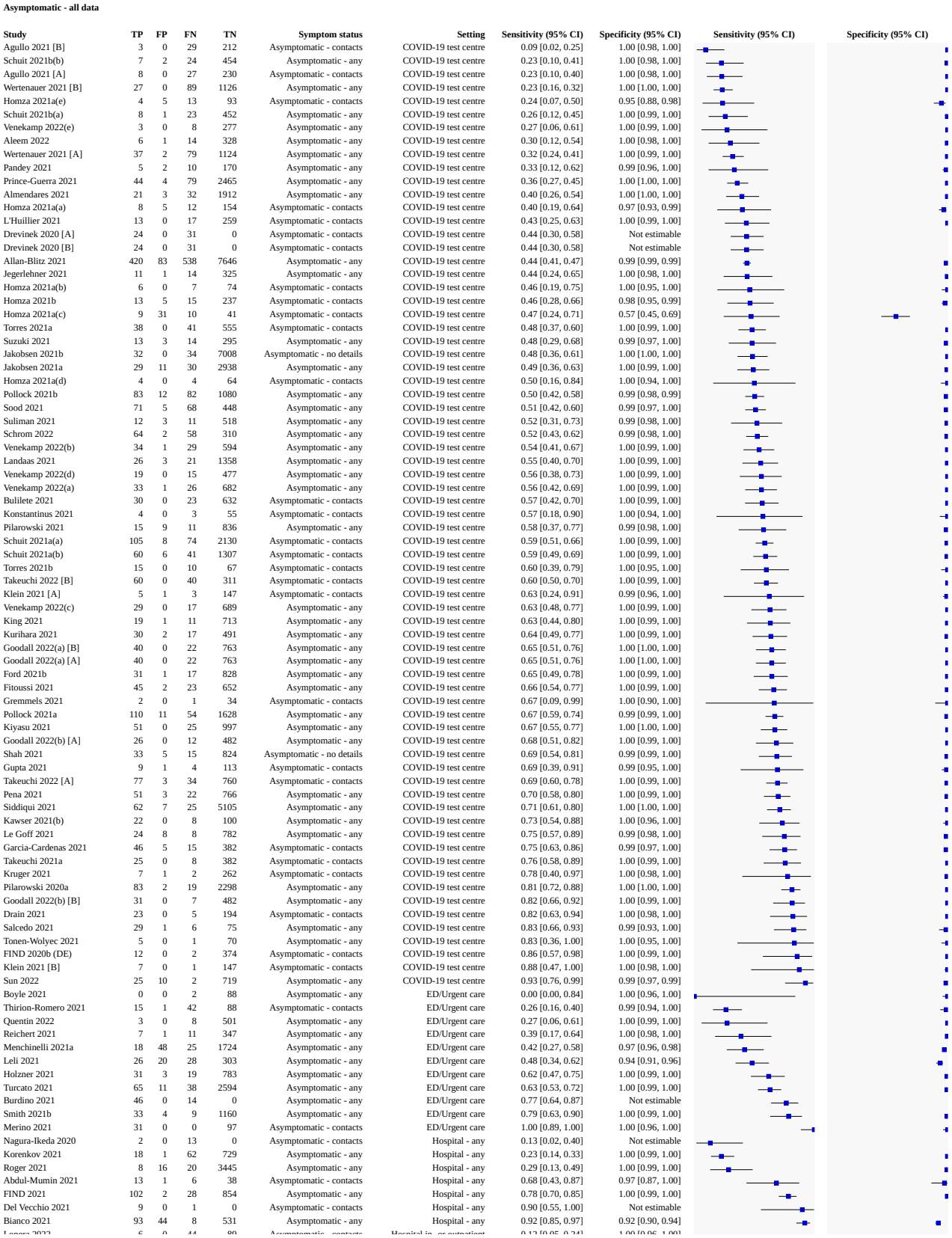
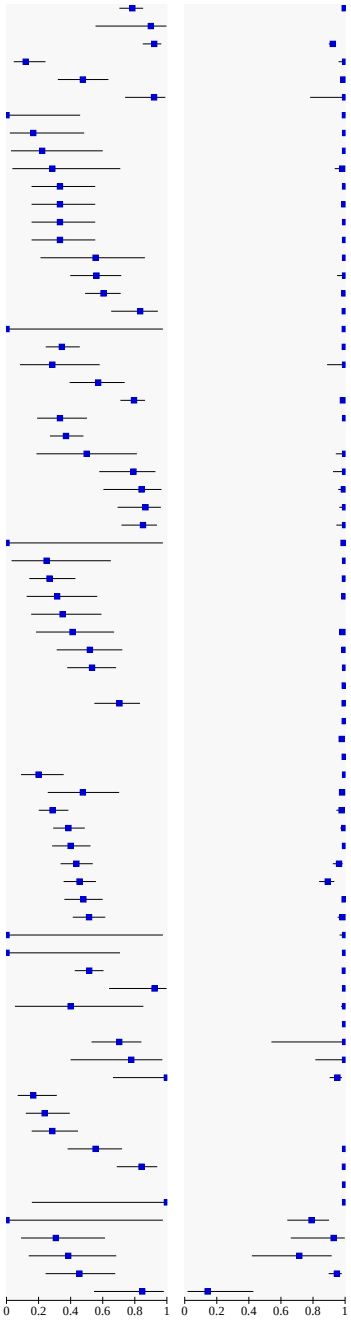


Figure 4. (Continued)

PHND 2021	102	2	26	654	Asymptomatic - any	Hospital - any	0.78 [0.70, 0.85]	1.00 [0.99, 1.00]
Del Vecchio 2021	9	0	1	0	Asymptomatic - contacts	Hospital - any	0.90 [0.55, 1.00]	Not estimable
Bianco 2021	93	44	8	531	Asymptomatic - any	Hospital - any	0.92 [0.85, 0.97]	0.92 [0.90, 0.94]
Lopera 2022	6	0	44	89	Asymptomatic - contacts	Hospital in- or outpatient	0.12 [0.05, 0.24]	1.00 [0.96, 1.00]
Kahn 2021	20	25	22	2273	Asymptomatic - any	Hospital in- or outpatient	0.48 [0.32, 0.64]	0.99 [0.98, 0.99]
Merino-Amador 2021	23	0	2	15	Asymptomatic - contacts	Hospital in- or outpatient	0.92 [0.74, 0.99]	1.00 [0.78, 1.00]
Stokes 2021	0	1	6	990	Asymptomatic - any	Hospital inpatient	0.00 [0.00, 0.46]	1.00 [0.99, 1.00]
Kumar 2021b	2	0	10	192	Asymptomatic - any	Hospital inpatient	0.17 [0.02, 0.48]	1.00 [0.98, 1.00]
Eleftheriou 2021	2	0	7	251	Asymptomatic - any	Hospital inpatient	0.22 [0.03, 0.60]	1.00 [0.99, 1.00]
Caruana 2021b	2	2	5	107	Asymptomatic - any	Hospital inpatient	0.29 [0.04, 0.71]	0.98 [0.94, 1.00]
Caruana 2021a [A]	8	0	16	215	Asymptomatic - any	Hospital inpatient	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [B]	8	1	16	214	Asymptomatic - any	Hospital inpatient	0.33 [0.16, 0.55]	1.00 [0.97, 1.00]
Caruana 2021a [C]	8	0	16	215	Asymptomatic - any	Hospital inpatient	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [D]	8	0	16	215	Asymptomatic - any	Hospital inpatient	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Rottenstreich 2021	5	0	4	1317	Asymptomatic - any	Hospital inpatient	0.56 [0.21, 0.86]	1.00 [1.00, 1.00]
Kanaujia 2021	23	0	18	72	Asymptomatic - contacts	Hospital inpatient	0.56 [0.40, 0.72]	1.00 [0.95, 1.00]
Brihn 2021	49	8	32	1643	Asymptomatic - no details	Hospital inpatient	0.60 [0.49, 0.71]	1.00 [0.99, 1.00]
Aranaz-Andrez 2021	25	1	5	510	Asymptomatic - any	Hospital inpatient	0.83 [0.65, 0.94]	1.00 [0.99, 1.00]
Zellmer 2021	0	1	1	527	Asymptomatic - any	Hospital outpatient	0.00 [0.00, 0.97]	1.00 [0.99, 1.00]
Thakur 2021	29	1	55	592	Asymptomatic - any	Hospital outpatient	0.35 [0.24, 0.46]	1.00 [0.99, 1.00]
Scohy 2020	4	0	10	31	Asymptomatic - no details	Laboratory-based	0.29 [0.08, 0.58]	1.00 [0.89, 1.00]
Halfon 2021	20	0	15	0	Asymptomatic - no details	Laboratory-based	0.57 [0.39, 0.74]	Not estimable
Alemany 2021	93	5	24	365	Asymptomatic - any	Laboratory-based	0.79 [0.71, 0.86]	0.99 [0.97, 1.00]
Masia 2021	13	0	26	253	Asymptomatic - contacts	Mixed	0.33 [0.19, 0.50]	1.00 [0.99, 1.00]
Boum 2021	33	0	56	0	Asymptomatic - any	Mixed	0.37 [0.27, 0.48]	Not estimable
Linares 2020	5	0	5	62	Asymptomatic - no details	Mixed	0.50 [0.19, 0.81]	1.00 [0.94, 1.00]
Cubas-Atienzar 2021a	19	0	5	47	Asymptomatic - any	Mixed	0.79 [0.58, 0.93]	1.00 [0.92, 1.00]
Muthamia 2022	16	1	3	127	Asymptomatic - any	Mixed	0.84 [0.60, 0.97]	0.99 [0.96, 1.00]
Kawser 2021(a)	26	0	4	100	Asymptomatic - any	Mixed	0.87 [0.69, 0.96]	1.00 [0.96, 1.00]
Shrestha 2020	40	0	7	66	Asymptomatic - contacts	Quarantine	0.85 [0.72, 0.94]	1.00 [0.95, 1.00]
Kriemler 2021	0	6	1	623	Asymptomatic - any	School/University	0.00 [0.00, 0.97]	0.99 [0.98, 1.00]
Ferguson 2021	2	0	6	712	Asymptomatic - any	School/University	0.25 [0.03, 0.65]	1.00 [0.99, 1.00]
Blanchard 2021	11	7	30	7019	Asymptomatic - any	School/University	0.27 [0.14, 0.43]	1.00 [1.00, 1.00]
Harris 2021	6	7	13	1525	Asymptomatic - any	School/University	0.32 [0.13, 0.57]	1.00 [0.99, 1.00]
Ferte 2021	7	0	13	0	Asymptomatic - any	School/University	0.35 [0.15, 0.59]	Not estimable
Pray 2021	7	14	10	840	Asymptomatic - any	School/University	0.41 [0.18, 0.67]	0.98 [0.97, 0.99]
Billaud 2020	13	1	12	289	Asymptomatic - contacts	School/University	0.52 [0.31, 0.72]	1.00 [0.98, 1.00]
Okoye 2021	24	0	21	2593	Asymptomatic - any	School/University	0.53 [0.38, 0.68]	1.00 [1.00, 1.00]
Iftner 2022(d)	0	1	0	462	Asymptomatic - any	School/University	Not estimable	1.00 [0.99, 1.00]
Fernandez-Montero 2021	31	7	13	2465	Asymptomatic - any	School/University	0.70 [0.55, 0.83]	1.00 [0.99, 1.00]
Iftner 2022(a)	0	1	0	462	Asymptomatic - any	School/University	Not estimable	1.00 [0.99, 1.00]
Iftner 2022(b)	0	10	0	466	Asymptomatic - any	School/University	Not estimable	0.98 [0.96, 0.99]
Iftner 2022(c)	0	1	0	453	Asymptomatic - any	School/University	Not estimable	1.00 [0.99, 1.00]
Tinker 2021	8	0	32	1500	Asymptomatic - any	School/University	0.20 [0.09, 0.36]	1.00 [1.00, 1.00]
Ford 2021a	10	16	11	836	Asymptomatic - any	School/University	0.48 [0.26, 0.70]	0.98 [0.97, 0.99]
Baro 2021 [E]	29	4	72	181	Asymptomatic - any	Screening - community	0.29 [0.20, 0.39]	0.98 [0.95, 0.99]
Baro 2021 [A]	39	1	62	184	Asymptomatic - any	Screening - community	0.39 [0.29, 0.49]	0.99 [0.97, 1.00]
Garcia-Finana 2021	28	3	42	5431	Asymptomatic - any	Screening - community	0.40 [0.28, 0.52]	1.00 [1.00, 1.00]
Baro 2021 [C]	44	7	57	178	Asymptomatic - any	Screening - community	0.44 [0.34, 0.54]	0.96 [0.92, 0.98]
Baro 2021 [D]	46	20	55	165	Asymptomatic - any	Screening - community	0.46 [0.36, 0.56]	0.89 [0.84, 0.93]
Mungomklang 2021	35	3	38	1024	Asymptomatic - any	Screening - community	0.48 [0.36, 0.60]	1.00 [0.99, 1.00]
Baro 2021 [B]	52	3	49	182	Asymptomatic - any	Screening - community	0.51 [0.41, 0.62]	0.98 [0.95, 1.00]
Osmanodja 2021	0	0	1	105	Asymptomatic - any	Screening - HCW	0.00 [0.00, 0.97]	1.00 [0.97, 1.00]
Farfour 2021	0	0	3	189	Asymptomatic - contacts	Screening - HCW	0.00 [0.00, 0.71]	1.00 [0.98, 1.00]
James 2021	66	3	62	2093	Asymptomatic - any	Screening - HCW	0.52 [0.43, 0.60]	1.00 [1.00, 1.00]
Von Ahnen 2021	12	0	1	906	Asymptomatic - any	Screening - HCW	0.92 [0.64, 1.00]	1.00 [1.00, 1.00]
Cerutti 2020	2	0	3	140	Asymptomatic - any	Screening - traveller	0.40 [0.05, 0.85]	1.00 [0.97, 1.00]
Qahtani 2021	0	0	0	592	Asymptomatic - any	Screening - traveller	Not estimable	1.00 [0.99, 1.00]
Diez Flecha 2021	26	0	11	6	Asymptomatic - any	Shared living facility	0.70 [0.53, 0.84]	1.00 [0.54, 1.00]
Fernandez 2022	7	0	2	18	Asymptomatic - contacts	Shared living facility	0.78 [0.40, 0.97]	1.00 [0.81, 1.00]
Ifko 2021	9	7	0	139	Asymptomatic - any	Shared living facility	1.00 [0.66, 1.00]	0.95 [0.90, 0.98]
Zobrist 2022 [B]	7	0	35	0	Asymptomatic - contacts	Targeted screening	0.17 [0.07, 0.31]	Not estimable
Zobrist 2022 [C]	10	0	32	0	Asymptomatic - contacts	Targeted screening	0.24 [0.12, 0.39]	Not estimable
Zobrist 2022 [A]	12	0	30	0	Asymptomatic - contacts	Targeted screening	0.29 [0.16, 0.45]	Not estimable
Di Domenico 2021	20	0	16	397	Asymptomatic - any	Targeted screening	0.56 [0.38, 0.72]	1.00 [0.99, 1.00]
Chiu 2021	32	18	6	22938	Asymptomatic - any	Targeted screening	0.84 [0.69, 0.94]	1.00 [1.00, 1.00]
Revollo 2021 [A]	0	0	0	465	Asymptomatic - any	Targeted screening	Not estimable	1.00 [0.99, 1.00]
Revollo 2021 [B]	2	0	0	493	Asymptomatic - any	Targeted screening	1.00 [0.16, 1.00]	1.00 [0.99, 1.00]
Parada-Ricart 2021	0	9	1	34	Asymptomatic - no details	Unclear	0.00 [0.00, 0.97]	0.79 [0.64, 0.90]
Schildgen 2021 [A]	4	1	9	13	Asymptomatic - no details	Unclear	0.31 [0.09, 0.61]	0.93 [0.66, 1.00]
Schildgen 2021 [B]	5	4	8	10	Asymptomatic - no details	Unclear	0.38 [0.14, 0.68]	0.71 [0.42, 0.92]
Fenollar 2020	10	7	12	130	Asymptomatic - contacts	Unclear	0.45 [0.24, 0.68]	0.95 [0.90, 0.98]
Schildgen 2021 [C]	11	12	2	2	Asymptomatic - no details	Unclear	0.85 [0.55, 0.98]	0.14 [0.02, 0.43]



Mainly asymptomatic - for primary analysis

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Bonde 2021	24	1	18	737	Mainly asymptomatic	Hospital - any	0.57 [0.41, 0.72]	1.00 [0.99, 1.00]
Nalumansi 2021	63	13	27	159	Mainly asymptomatic	Hospital - any	0.70 [0.59, 0.79]	0.92 [0.87, 0.96]
Agarwal 2021	26	2	3	436	Mainly asymptomatic	Hospital - any	0.90 [0.73, 0.98]	1.00 [0.98, 1.00]
Alghounaim 2021	19	11	43	898	Mainly asymptomatic	Screening - community	0.31 [0.20, 0.44]	0.99 [0.98, 0.99]
Escriva 2021	99	0	18	331	Mainly asymptomatic	Shared living facility	0.85 [0.77, 0.91]	1.00 [0.99, 1.00]

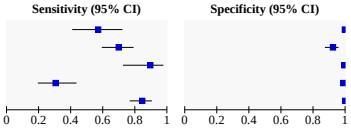


Figure 5. Forest plot of data for antigen tests for asymptomatic populations by reported exposure to SARS-CoV-2

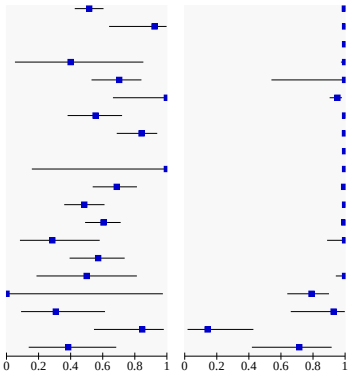
DE: Germany; ED: emergency department; HCW: healthcare worker

Asymptomatic - any

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Goodall 2022(a) [A]	40	0	22	763	COVID-19 test centre	Asymptomatic - any	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Aleem 2022	6	1	14	328	COVID-19 test centre	Asymptomatic - any	0.30 [0.12, 0.54]	1.00 [0.98, 1.00]
Allan-Blitz 2021	420	83	538	7646	COVID-19 test centre	Asymptomatic - any	0.44 [0.41, 0.47]	0.99 [0.99, 0.99]
Pilarowski 2021	15	9	11	836	COVID-19 test centre	Asymptomatic - any	0.58 [0.37, 0.77]	0.99 [0.98, 1.00]
Pandey 2021	5	2	10	170	COVID-19 test centre	Asymptomatic - any	0.33 [0.12, 0.62]	0.99 [0.96, 1.00]
Goodall 2022(a) [B]	40	0	22	763	COVID-19 test centre	Asymptomatic - any	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Ford 2021b	31	1	17	828	COVID-19 test centre	Asymptomatic - any	0.65 [0.49, 0.78]	1.00 [0.99, 1.00]
Goodall 2022(b) [A]	26	0	12	482	COVID-19 test centre	Asymptomatic - any	0.68 [0.51, 0.82]	1.00 [0.99, 1.00]
Goodall 2022(b) [B]	31	0	7	482	COVID-19 test centre	Asymptomatic - any	0.82 [0.66, 0.92]	1.00 [0.99, 1.00]
Fitoussi 2021	45	2	23	652	COVID-19 test centre	Asymptomatic - any	0.66 [0.54, 0.77]	1.00 [0.99, 1.00]
Sood 2021	71	5	68	448	COVID-19 test centre	Asymptomatic - any	0.51 [0.42, 0.60]	0.99 [0.97, 1.00]
Pena 2021	51	3	22	766	COVID-19 test centre	Asymptomatic - any	0.70 [0.58, 0.80]	1.00 [0.99, 1.00]
Kiyasu 2021	51	0	25	997	COVID-19 test centre	Asymptomatic - any	0.67 [0.55, 0.77]	1.00 [1.00, 1.00]
Pilarowski 2020a	83	2	19	2298	COVID-19 test centre	Asymptomatic - any	0.81 [0.72, 0.88]	1.00 [1.00, 1.00]
Pollock 2021a	110	11	54	1628	COVID-19 test centre	Asymptomatic - any	0.67 [0.59, 0.74]	0.99 [0.99, 1.00]
Pollock 2021b	83	12	82	1080	COVID-19 test centre	Asymptomatic - any	0.50 [0.42, 0.58]	0.99 [0.98, 0.99]
Prince-Guerra 2021	44	4	79	2465	COVID-19 test centre	Asymptomatic - any	0.36 [0.27, 0.45]	1.00 [1.00, 1.00]
Jakobsen 2021a	29	11	30	2938	COVID-19 test centre	Asymptomatic - any	0.49 [0.36, 0.63]	1.00 [0.99, 1.00]
Jegerlehner 2021	11	1	14	325	COVID-19 test centre	Asymptomatic - any	0.44 [0.24, 0.65]	1.00 [0.98, 1.00]
Suliman 2021	12	3	11	518	COVID-19 test centre	Asymptomatic - any	0.52 [0.31, 0.73]	0.99 [0.98, 1.00]
Kawser 2021(b)	22	0	8	100	COVID-19 test centre	Asymptomatic - any	0.73 [0.54, 0.88]	1.00 [0.96, 1.00]
Le Goff 2021	24	8	8	782	COVID-19 test centre	Asymptomatic - any	0.75 [0.57, 0.89]	0.99 [0.98, 1.00]
Kurihara 2021	30	2	17	491	COVID-19 test centre	Asymptomatic - any	0.64 [0.49, 0.77]	1.00 [0.99, 1.00]
Landaas 2021	26	3	21	1358	COVID-19 test centre	Asymptomatic - any	0.55 [0.40, 0.70]	1.00 [0.99, 1.00]
Tonen-Wolyec 2021	5	0	1	70	COVID-19 test centre	Asymptomatic - any	0.83 [0.36, 1.00]	1.00 [0.95, 1.00]
Venekamp 2022(e)	3	0	8	277	COVID-19 test centre	Asymptomatic - any	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]
Suzuki 2021	13	3	14	295	COVID-19 test centre	Asymptomatic - any	0.48 [0.29, 0.68]	0.99 [0.97, 1.00]
Venekamp 2022(c)	29	0	17	689	COVID-19 test centre	Asymptomatic - any	0.63 [0.48, 0.77]	1.00 [0.99, 1.00]
Venekamp 2022(b)	34	1	29	594	COVID-19 test centre	Asymptomatic - any	0.54 [0.41, 0.67]	1.00 [0.99, 1.00]
Salcedo 2021	29	1	6	75	COVID-19 test centre	Asymptomatic - any	0.83 [0.66, 0.93]	0.99 [0.93, 1.00]
Schrom 2022	64	2	58	310	COVID-19 test centre	Asymptomatic - any	0.52 [0.43, 0.62]	0.99 [0.98, 1.00]
Schuit 2021b(b)	7	2	24	454	COVID-19 test centre	Asymptomatic - any	0.23 [0.10, 0.41]	1.00 [0.98, 1.00]
Schuit 2021b(a)	8	1	23	452	COVID-19 test centre	Asymptomatic - any	0.26 [0.12, 0.45]	1.00 [0.99, 1.00]
Torres 2021b	15	0	10	67	COVID-19 test centre	Asymptomatic - any	0.60 [0.39, 0.79]	1.00 [0.95, 1.00]
Venekamp 2022(a)	33	1	26	682	COVID-19 test centre	Asymptomatic - any	0.56 [0.42, 0.69]	1.00 [0.99, 1.00]
Wertenauer 2021 [A]	37	2	79	1124	COVID-19 test centre	Asymptomatic - any	0.32 [0.24, 0.41]	1.00 [0.99, 1.00]
Venekamp 2022(d)	19	0	15	477	COVID-19 test centre	Asymptomatic - any	0.56 [0.38, 0.73]	1.00 [0.99, 1.00]
Wertenauer 2021 [B]	27	0	89	1126	COVID-19 test centre	Asymptomatic - any	0.23 [0.16, 0.32]	1.00 [1.00, 1.00]
Burdino 2021	46	0	14	0	ED/Urgent care	Asymptomatic - any	0.77 [0.64, 0.87]	Not estimable
Quentin 2022	3	0	8	501	ED/Urgent care	Asymptomatic - any	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]
Menchinelli 2021a	18	48	25	1724	ED/Urgent care	Asymptomatic - any	0.42 [0.27, 0.58]	0.97 [0.96, 0.98]
Boyle 2021	0	0	2	88	ED/Urgent care	Asymptomatic - any	0.00 [0.00, 0.84]	1.00 [0.96, 1.00]
Smith 2021b	33	4	9	1160	ED/Urgent care	Asymptomatic - any	0.79 [0.63, 0.90]	1.00 [0.99, 1.00]
Holzner 2021	31	3	19	783	ED/Urgent care	Asymptomatic - any	0.62 [0.47, 0.75]	1.00 [0.99, 1.00]
Leli 2021	26	20	28	303	ED/Urgent care	Asymptomatic - any	0.48 [0.34, 0.62]	0.94 [0.91, 0.96]
Turcato 2021	65	11	38	2594	ED/Urgent care	Asymptomatic - any	0.63 [0.53, 0.72]	1.00 [0.99, 1.00]
Reichert 2021	7	1	11	347	ED/Urgent care	Asymptomatic - any	0.39 [0.17, 0.64]	1.00 [0.98, 1.00]
Bianco 2021	93	44	8	531	Hospital - any	Asymptomatic - any	0.92 [0.85, 0.97]	0.92 [0.90, 0.94]
Korenkov 2021	18	1	62	729	Hospital - any	Asymptomatic - any	0.23 [0.14, 0.33]	1.00 [0.99, 1.00]
Roger 2021	8	16	20	3445	Hospital - any	Asymptomatic - any	0.29 [0.13, 0.49]	1.00 [0.99, 1.00]
Kahn 2021	20	25	22	2273	Hospital in- or outpatient	Asymptomatic - any	0.48 [0.32, 0.64]	0.99 [0.98, 0.99]
Caruana 2021a [A]	8	0	16	215	Hospital inpatient	Asymptomatic - any	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [C]	8	0	16	215	Hospital inpatient	Asymptomatic - any	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Aranaz-Andrez 2021	25	1	5	510	Hospital inpatient	Asymptomatic - any	0.83 [0.65, 0.94]	1.00 [0.99, 1.00]
Caruana 2021b	2	2	5	107	Hospital inpatient	Asymptomatic - any	0.29 [0.04, 0.71]	0.98 [0.94, 1.00]
Caruana 2021a [D]	8	0	16	215	Hospital inpatient	Asymptomatic - any	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [B]	8	1	16	214	Hospital inpatient	Asymptomatic - any	0.33 [0.16, 0.55]	1.00 [0.97, 1.00]
Eleftheriou 2021	2	0	7	251	Hospital inpatient	Asymptomatic - any	0.22 [0.03, 0.60]	1.00 [0.99, 1.00]
Stokes 2021	0	1	6	990	Hospital inpatient	Asymptomatic - any	0.00 [0.00, 0.46]	1.00 [0.99, 1.00]
Kumar 2021b	2	0	10	192	Hospital inpatient	Asymptomatic - any	0.17 [0.02, 0.48]	1.00 [0.98, 1.00]
Rottenstreich 2021	5	0	4	1317	Hospital inpatient	Asymptomatic - any	0.56 [0.21, 0.86]	1.00 [1.00, 1.00]
Thakur 2021	29	1	55	592	Hospital outpatient	Asymptomatic - any	0.35 [0.24, 0.46]	1.00 [0.99, 1.00]
Zellmer 2021	0	1	1	527	Hospital outpatient	Asymptomatic - any	0.00 [0.00, 0.97]	1.00 [0.99, 1.00]
Muthamia 2022	16	1	3	127	Mixed	Asymptomatic - any	0.84 [0.60, 0.97]	0.99 [0.96, 1.00]
Boum 2021	33	0	56	0	Mixed	Asymptomatic - any	0.37 [0.27, 0.48]	Not estimable
Cubas-Atienzar 2021a	19	0	5	47	Mixed	Asymptomatic - any	0.79 [0.58, 0.93]	1.00 [0.92, 1.00]
Kawser 2021(a)	26	0	4	100	Mixed	Asymptomatic - any	0.87 [0.69, 0.96]	1.00 [0.96, 1.00]
Pray 2021	7	14	10	840	School/University	Asymptomatic - any	0.41 [0.18, 0.67]	0.98 [0.97, 0.99]
Okoye 2021	24	0	21	2593	School/University	Asymptomatic - any	0.53 [0.38, 0.68]	1.00 [1.00, 1.00]
Iftner 2022(d)	0	1	0	462	School/University	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Ferguson 2021	2	0	6	712	School/University	Asymptomatic - any	0.25 [0.03, 0.65]	1.00 [0.99, 1.00]
Harris 2021	6	7	13	1525	School/University	Asymptomatic - any	0.32 [0.13, 0.57]	1.00 [0.99, 1.00]
Ferte 2021	7	0	13	0	School/University	Asymptomatic - any	0.35 [0.15, 0.59]	Not estimable
Ford 2021a	7	14	9	802	School/University	Asymptomatic - any	0.44 [0.20, 0.70]	0.98 [0.97, 0.99]
Iftner 2022(a)	0	1	0	462	School/University	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Iftner 2022(b)	0	10	0	466	School/University	Asymptomatic - any	Not estimable	0.98 [0.96, 0.99]
Iftner 2022(c)	0	1	0	453	School/University	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Tinker 2021	8	0	32	1500	School/University	Asymptomatic - any	0.20 [0.09, 0.36]	1.00 [1.00, 1.00]
Baro 2021 [D]	46	20	55	165	Screening - community	Asymptomatic - any	0.46 [0.36, 0.56]	0.89 [0.84, 0.93]
Baro 2021 [B]	52	3	49	182	Screening - community	Asymptomatic - any	0.51 [0.41, 0.62]	0.98 [0.95, 1.00]
Baro 2021 [C]	44	7	57	178	Screening - community	Asymptomatic - any	0.44 [0.34, 0.54]	0.96 [0.92, 0.98]
Baro 2021 [A]	39	1	62	184	Screening - community	Asymptomatic - any	0.39 [0.29, 0.49]	0.99 [0.97, 1.00]
Baro 2021 [E]	29	4	72	181	Screening - community	Asymptomatic - any	0.29 [0.20, 0.39]	0.98 [0.95, 0.99]
Mungomklang 2021	35	3	38	1024	Screening - community	Asymptomatic - any	0.48 [0.36, 0.60]	1.00 [0.99, 1.00]
Garcia-Finana 2021	28	3	42	5431	Screening - community	Asymptomatic - any	0.40 [0.28, 0.52]	1.00 [1.00, 1.00]
Osmanodja 2021	0	0	1	105	Screening - HCW	Asymptomatic - any	0.00 [0.00, 0.97]	1.00 [0.97, 1.00]
James 2021	66	3	62	2093	Screening - HCW	Asymptomatic - any	0.52 [0.43, 0.60]	1.00 [1.00, 1.00]
Von Ahnen 2021	12	0	1	906	Screening - HCW	Asymptomatic - any	0.92 [0.64, 1.00]	1.00 [1.00, 1.00]
Qahtani 2021	0	0	0	592	Screening - traveller	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Conutti 2020	2	0	3	140	Screening - traveller	Asymptomatic - any	0.40 [0.05, 0.85]	1.00 [0.97, 1.00]

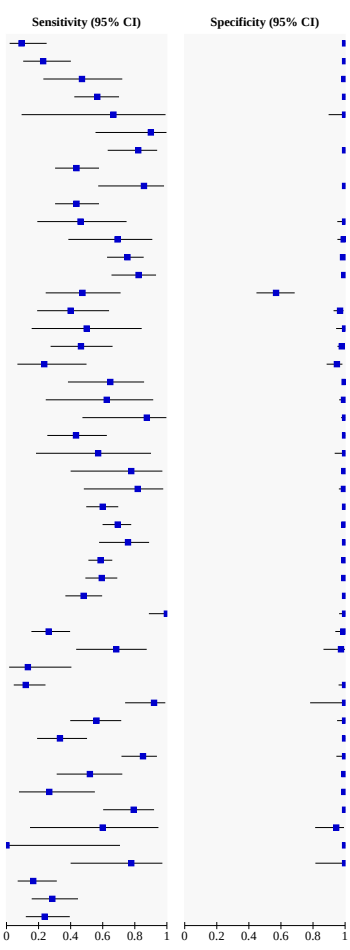
Figure 5. (Continued)

James 2021	66	3	62	2093	Screening - HCW	Asymptomatic - any	0.52 [0.43, 0.60]	1.00 [1.00, 1.00]
Von Ahnen 2021	12	0	1	906	Screening - HCW	Asymptomatic - any	0.92 [0.64, 1.00]	1.00 [1.00, 1.00]
Qahtani 2021	0	0	0	592	Screening - traveller	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Cerutti 2020	2	0	3	140	Screening - traveller	Asymptomatic - any	0.40 [0.05, 0.85]	1.00 [0.97, 1.00]
Diez Flecha 2021	26	0	11	6	Shared living facility	Asymptomatic - any	0.70 [0.53, 0.84]	1.00 [0.54, 1.00]
Ifko 2021	9	7	0	139	Shared living facility	Asymptomatic - any	1.00 [0.66, 1.00]	0.95 [0.90, 0.98]
Di Domenico 2021	20	0	16	397	Targeted screening	Asymptomatic - any	0.56 [0.38, 0.72]	1.00 [0.99, 1.00]
Chiu 2021	32	18	6	22938	Targeted screening	Asymptomatic - any	0.84 [0.69, 0.94]	1.00 [1.00, 1.00]
Revollo 2021 [A]	0	0	0	465	Targeted screening	Asymptomatic - any	Not estimable	1.00 [0.99, 1.00]
Revollo 2021 [B]	2	0	0	493	Targeted screening	Asymptomatic - any	1.00 [0.16, 1.00]	1.00 [0.99, 1.00]
Shah 2021	33	5	15	824	COVID-19 test centre	Asymptomatic - no details	0.69 [0.54, 0.81]	0.99 [0.99, 1.00]
Jakobsen 2021b	32	0	34	7008	COVID-19 test centre	Asymptomatic - no details	0.48 [0.36, 0.61]	1.00 [1.00, 1.00]
Brihn 2021	49	8	32	1643	Hospital inpatient	Asymptomatic - no details	0.60 [0.49, 0.71]	1.00 [0.99, 1.00]
Scohy 2020	4	0	10	31	Laboratory-based	Asymptomatic - no details	0.29 [0.08, 0.58]	1.00 [0.89, 1.00]
Halfon 2021	20	0	15	0	Laboratory-based	Asymptomatic - no details	0.57 [0.39, 0.74]	Not estimable
Linares 2020	5	0	5	62	Mixed	Asymptomatic - no details	0.50 [0.19, 0.81]	1.00 [0.94, 1.00]
Parada-Ricart 2021	0	9	1	34	Unclear	Asymptomatic - no details	0.00 [0.00, 0.97]	0.79 [0.64, 0.90]
Schildgen 2021 [A]	4	1	9	13	Unclear	Asymptomatic - no details	0.31 [0.09, 0.61]	0.93 [0.66, 1.00]
Schildgen 2021 [C]	11	12	2	2	Unclear	Asymptomatic - no details	0.85 [0.55, 0.98]	0.14 [0.02, 0.43]
Schildgen 2021 [B]	5	4	8	10	Unclear	Asymptomatic - no details	0.38 [0.14, 0.68]	0.71 [0.42, 0.92]



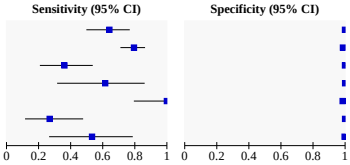
Asymptomatic - contacts/exposure reported

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Agullo 2021 [B]	3	0	29	212	COVID-19 test centre	Asymptomatic - contacts	0.09 [0.02, 0.25]	1.00 [0.98, 1.00]
Agullo 2021 [A]	8	0	27	230	COVID-19 test centre	Asymptomatic - contacts	0.23 [0.10, 0.40]	1.00 [0.98, 1.00]
Almendares 2021	8	2	9	537	COVID-19 test centre	Asymptomatic - contacts	0.47 [0.23, 0.72]	1.00 [0.99, 1.00]
Bulilete 2021	30	0	23	632	COVID-19 test centre	Asymptomatic - contacts	0.57 [0.42, 0.70]	1.00 [0.99, 1.00]
Gremmels 2021	2	0	1	34	COVID-19 test centre	Asymptomatic - contacts	0.67 [0.09, 0.99]	1.00 [0.90, 1.00]
Del Vecchio 2021	9	0	1	0	COVID-19 test centre	Asymptomatic - contacts	0.90 [0.55, 1.00]	Not estimable
Drain 2021	23	0	5	194	COVID-19 test centre	Asymptomatic - contacts	0.82 [0.63, 0.94]	1.00 [0.98, 1.00]
Drevinek 2020 [B]	24	0	31	0	COVID-19 test centre	Asymptomatic - contacts	0.44 [0.30, 0.58]	Not estimable
FIND 2020b (DE)	12	0	2	374	COVID-19 test centre	Asymptomatic - contacts	0.86 [0.57, 0.98]	1.00 [0.99, 1.00]
Drevinek 2020 [A]	24	0	31	0	COVID-19 test centre	Asymptomatic - contacts	0.44 [0.30, 0.58]	Not estimable
Homza 2021a(b)	6	0	7	74	COVID-19 test centre	Asymptomatic - contacts	0.46 [0.19, 0.75]	1.00 [0.95, 1.00]
Gupta 2021	9	1	4	113	COVID-19 test centre	Asymptomatic - contacts	0.69 [0.39, 0.91]	0.99 [0.95, 1.00]
Garcia-Cardenas 2021	46	5	15	382	COVID-19 test centre	Asymptomatic - contacts	0.75 [0.63, 0.86]	0.99 [0.97, 1.00]
Siddiqui 2021	28	4	6	848	COVID-19 test centre	Asymptomatic - contacts	0.82 [0.65, 0.93]	1.00 [0.99, 1.00]
Homza 2021a(c)	9	31	10	41	COVID-19 test centre	Asymptomatic - contacts	0.47 [0.24, 0.71]	0.57 [0.45, 0.69]
Homza 2021a(a)	8	5	12	154	COVID-19 test centre	Asymptomatic - contacts	0.40 [0.19, 0.64]	0.97 [0.93, 0.99]
Homza 2021a(d)	4	0	4	64	COVID-19 test centre	Asymptomatic - contacts	0.50 [0.16, 0.84]	1.00 [0.94, 1.00]
Homza 2021b	13	5	15	237	COVID-19 test centre	Asymptomatic - contacts	0.46 [0.28, 0.66]	0.98 [0.95, 0.99]
Homza 2021a(e)	4	5	13	93	COVID-19 test centre	Asymptomatic - contacts	0.24 [0.07, 0.50]	0.95 [0.88, 0.98]
King 2021	11	1	6	352	COVID-19 test centre	Asymptomatic - contacts	0.65 [0.38, 0.86]	1.00 [0.98, 1.00]
Klein 2021 [A]	5	1	3	147	COVID-19 test centre	Asymptomatic - contacts	0.63 [0.24, 0.91]	0.99 [0.96, 1.00]
Klein 2021 [B]	7	0	1	147	COVID-19 test centre	Asymptomatic - contacts	0.88 [0.47, 1.00]	1.00 [0.98, 1.00]
L'Huillier 2021	13	0	17	259	COVID-19 test centre	Asymptomatic - contacts	0.43 [0.25, 0.63]	1.00 [0.99, 1.00]
Konstantinus 2021	4	0	3	55	COVID-19 test centre	Asymptomatic - contacts	0.57 [0.18, 0.90]	1.00 [0.94, 1.00]
Kruger 2021	7	1	2	262	COVID-19 test centre	Asymptomatic - contacts	0.78 [0.40, 0.97]	1.00 [0.98, 1.00]
Sun 2022	9	1	2	140	COVID-19 test centre	Asymptomatic - contacts	0.82 [0.48, 0.98]	0.99 [0.96, 1.00]
Takeuchi 2022 [B]	60	0	40	311	COVID-19 test centre	Asymptomatic - contacts	0.60 [0.50, 0.70]	1.00 [0.99, 1.00]
Takeuchi 2022 [A]	77	3	34	760	COVID-19 test centre	Asymptomatic - contacts	0.69 [0.60, 0.78]	1.00 [0.99, 1.00]
Takeuchi 2021a	25	0	8	382	COVID-19 test centre	Asymptomatic - contacts	0.76 [0.58, 0.89]	1.00 [0.99, 1.00]
Schuit 2021a(a)	105	8	74	2130	COVID-19 test centre	Asymptomatic - contacts	0.59 [0.51, 0.66]	1.00 [0.99, 1.00]
Schuit 2021a(b)	60	6	41	1307	COVID-19 test centre	Asymptomatic - contacts	0.59 [0.49, 0.69]	1.00 [0.99, 1.00]
Torres 2021a	38	0	41	555	COVID-19 test centre	Asymptomatic - contacts	0.48 [0.37, 0.60]	1.00 [0.99, 1.00]
Merino 2021	31	0	0	97	ED/Urgent care	Asymptomatic - contacts	1.00 [0.89, 1.00]	1.00 [0.96, 1.00]
Thirion-Romero 2021	15	1	42	88	ED/Urgent care	Asymptomatic - contacts	0.26 [0.16, 0.40]	0.99 [0.94, 1.00]
Abdul-Mumin 2021	13	1	6	38	Hospital - any	Asymptomatic - contacts	0.68 [0.43, 0.87]	0.97 [0.87, 1.00]
Nagura-Ikeda 2020	2	0	13	0	Hospital - any	Asymptomatic - contacts	0.13 [0.02, 0.40]	Not estimable
Lopera 2022	6	0	44	89	Hospital in- or outpatient	Asymptomatic - contacts	0.12 [0.05, 0.24]	1.00 [0.96, 1.00]
Merino-Amador 2021	23	0	2	15	Hospital in- or outpatient	Asymptomatic - contacts	0.92 [0.74, 0.99]	1.00 [0.78, 1.00]
Kanaujia 2021	23	0	18	72	Hospital inpatient	Asymptomatic - contacts	0.56 [0.40, 0.72]	1.00 [0.95, 1.00]
Masia 2021	13	0	26	253	Mixed	Asymptomatic - contacts	0.33 [0.19, 0.50]	1.00 [0.99, 1.00]
Shrestha 2020	40	0	7	66	Quarantine	Asymptomatic - contacts	0.85 [0.72, 0.94]	1.00 [0.95, 1.00]
Billaud 2020	13	1	12	289	School/University	Asymptomatic - contacts	0.52 [0.31, 0.72]	1.00 [0.98, 1.00]
Blanchard 2021	4	6	11	1470	School/University	Asymptomatic - contacts	0.27 [0.08, 0.55]	1.00 [0.99, 1.00]
Fernandez-Montero 2021	23	0	6	199	School/University	Asymptomatic - contacts	0.79 [0.60, 0.92]	1.00 [0.98, 1.00]
Ford 2021a	3	2	2	34	School/University	Asymptomatic - contacts	0.60 [0.15, 0.95]	0.94 [0.81, 0.99]
Farfour 2021	0	0	3	189	Screening - HCW	Asymptomatic - contacts	0.00 [0.00, 0.71]	1.00 [0.98, 1.00]
Fernandez 2022	7	0	2	18	Shared living facility	Asymptomatic - contacts	0.78 [0.40, 0.97]	1.00 [0.81, 1.00]
Zobrist 2022 [B]	7	0	35	0	Targeted screening	Asymptomatic - contacts	0.17 [0.07, 0.31]	Not estimable
Zobrist 2022 [A]	12	0	30	0	Targeted screening	Asymptomatic - contacts	0.29 [0.16, 0.45]	Not estimable
Zobrist 2022 [C]	10	0	32	0	Targeted screening	Asymptomatic - contacts	0.24 [0.12, 0.39]	Not estimable



Asymptomatic - no exposure reported

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Siddiqui 2021	34	3	19	4257	COVID-19 test centre	Asymptomatic - any	0.64 [0.50, 0.77]	1.00 [1.00, 1.00]
Alemany 2021	93	5	24	365	COVID-19 test centre	Asymptomatic - any	0.79 [0.71, 0.86]	0.99 [0.97, 1.00]
Almendares 2021	13	1	23	1375	COVID-19 test centre	Asymptomatic - any	0.36 [0.21, 0.54]	1.00 [1.00, 1.00]
King 2021	8	0	5	361	COVID-19 test centre	Asymptomatic - any	0.62 [0.32, 0.86]	1.00 [0.99, 1.00]
Sun 2022	16	9	0	579	COVID-19 test centre	Asymptomatic - any	1.00 [0.79, 1.00]	0.98 [0.97, 0.99]
Blanchard 2021	7	1	19	5549	School/University	Asymptomatic - any	0.27 [0.12, 0.48]	1.00 [1.00, 1.00]
Fernandez-Montero 2021	8	7	7	2266	School/University	Asymptomatic - any	0.53 [0.27, 0.79]	1.00 [0.99, 1.00]



Mainly asymptomatic - for subgroup by exposure

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Almendares 2021	157	4	142	3116	COVID-19 test centre	Mainly asymptomatic	0.53 [0.47, 0.58]	1.00 [1.00, 1.00]
Fitoussi 2021	121	3	27	816	COVID-19 test centre	Mainly asymptomatic	0.82 [0.75, 0.88]	1.00 [0.99, 1.00]
Prince-Guerra 2021	157	4	142	3115	COVID-19 test centre	Mainly asymptomatic	0.53 [0.47, 0.58]	1.00 [1.00, 1.00]
Schuit 2021a(a)	149	9	84	2436	COVID-19 test centre	Mainly asymptomatic	0.64 [0.57, 0.70]	1.00 [0.99, 1.00]

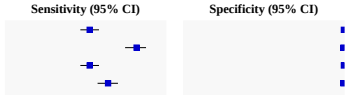


Figure 5. (Continued)

Fitoussi 2021	121	3	27	816	COVID-19 test centre	Mainly asymptomatic	0.82 [0.75, 0.88]	1.00 [0.99, 1.00]
Prince-Guerra 2021	157	4	142	3115	COVID-19 test centre	Mainly asymptomatic	0.53 [0.47, 0.58]	1.00 [1.00, 1.00]
Schuit 2021a(a)	149	9	84	2436	COVID-19 test centre	Mainly asymptomatic	0.64 [0.57, 0.70]	1.00 [0.99, 1.00]
Schuit 2021a(b)	83	8	49	1456	COVID-19 test centre	Mainly asymptomatic	0.63 [0.54, 0.71]	0.99 [0.99, 1.00]
Siddiqui 2021	179	13	43	5826	COVID-19 test centre	Mainly asymptomatic	0.81 [0.75, 0.86]	1.00 [1.00, 1.00]
Sood 2021	127	9	99	539	COVID-19 test centre	Mainly asymptomatic	0.56 [0.49, 0.63]	0.98 [0.97, 0.99]
Suliman 2021	25	3	26	577	COVID-19 test centre	Mainly asymptomatic	0.49 [0.35, 0.63]	0.99 [0.98, 1.00]
Bonde 2021	24	1	18	737	Hospital - any	Mainly asymptomatic	0.57 [0.41, 0.72]	1.00 [0.99, 1.00]
Nalumansi 2021	63	13	27	159	Hospital - any	Mainly asymptomatic	0.70 [0.59, 0.79]	0.92 [0.87, 0.96]
Roger 2021	86	33	102	4204	Hospital - any	Mainly asymptomatic	0.46 [0.38, 0.53]	0.99 [0.99, 0.99]
Agarwal 2021	26	2	3	436	Hospital - any	Mainly asymptomatic	0.90 [0.73, 0.98]	1.00 [0.98, 1.00]
Kahn 2021	57	31	39	2983	Hospital in- or outpatient	Mainly asymptomatic	0.59 [0.49, 0.69]	0.99 [0.99, 0.99]
Ford 2021a	37	15	17	982	School/University	Mainly asymptomatic	0.69 [0.54, 0.80]	0.98 [0.98, 0.99]
Pray 2021	39	16	18	1025	School/University	Mainly asymptomatic	0.68 [0.55, 0.80]	0.98 [0.98, 0.99]
Blanchard 2021	22	8	33	8140	School/University	Mainly asymptomatic	0.40 [0.27, 0.54]	1.00 [1.00, 1.00]
Ferte 2021	33	0	19	639	School/University	Mainly asymptomatic	0.63 [0.49, 0.76]	1.00 [0.99, 1.00]
Alghounaim 2021	19	11	43	898	Screening - community	Mainly asymptomatic	0.31 [0.20, 0.44]	0.99 [0.98, 0.99]
Escriva 2021	99	0	18	331	Shared living facility	Mainly asymptomatic	0.85 [0.77, 0.91]	1.00 [0.99, 1.00]
Diez Flecha 2021	36	0	13	6	Shared living facility	Mainly asymptomatic	0.73 [0.59, 0.85]	1.00 [0.54, 1.00]
Zobrist 2022 [C]	40	0	39	266	Targeted screening	Mainly asymptomatic	0.51 [0.39, 0.62]	1.00 [0.99, 1.00]
Zobrist 2022 [A]	44	0	36	260	Targeted screening	Mainly asymptomatic	0.55 [0.43, 0.66]	1.00 [0.99, 1.00]
Zobrist 2022 [B]	26	3	54	257	Targeted screening	Mainly asymptomatic	0.33 [0.22, 0.44]	0.99 [0.97, 1.00]

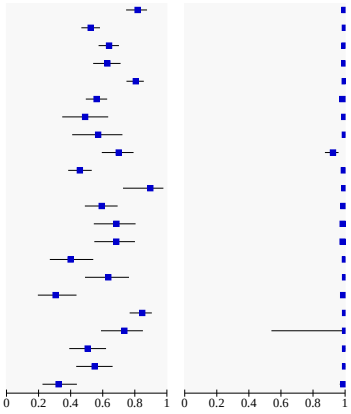


Figure 6. Forest plot of data for antigen tests for asymptomatic populations by reported exposure to SARS-CoV-2 (within-study comparisons)

Asymptomatic - contacts/exposure reported

Study	TP	FP	FN	TN	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Almendares 2021	8	2	9	537	COVID-19 test centre	0.47 [0.23, 0.72]	1.00 [0.99, 1.00]
King 2021	11	1	6	352	COVID-19 test centre	0.65 [0.38, 0.86]	1.00 [0.98, 1.00]
Siddiqui 2021	28	4	6	848	COVID-19 test centre	0.82 [0.65, 0.93]	1.00 [0.99, 1.00]
Sun 2022	9	1	2	140	COVID-19 test centre	0.82 [0.48, 0.98]	0.99 [0.96, 1.00]
Blanchard 2021	4	6	11	1470	School/University	0.27 [0.08, 0.55]	1.00 [0.99, 1.00]
Fernandez-Montero 2021	23	0	6	199	School/University	0.79 [0.60, 0.92]	1.00 [0.98, 1.00]

Asymptomatic - no exposure reported

Study	TP	FP	FN	TN	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Almendares 2021	13	1	23	1375	COVID-19 test centre	0.36 [0.21, 0.54]	1.00 [1.00, 1.00]
King 2021	8	0	5	361	COVID-19 test centre	0.62 [0.32, 0.86]	1.00 [0.99, 1.00]
Siddiqui 2021	34	3	19	4257	COVID-19 test centre	0.64 [0.50, 0.77]	1.00 [1.00, 1.00]
Sun 2022	16	9	0	579	COVID-19 test centre	1.00 [0.79, 1.00]	0.98 [0.97, 0.99]
Blanchard 2021	7	1	19	5549	School/University	0.27 [0.12, 0.48]	1.00 [1.00, 1.00]
Fernandez-Montero 2021	8	7	7	2266	School/University	0.53 [0.27, 0.79]	1.00 [0.99, 1.00]

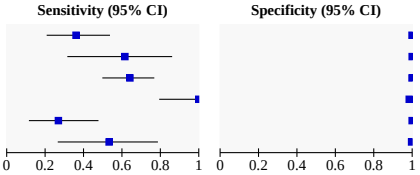


Figure 7. Forest plot of data for asymptomatic participants by week after contact with confirmed case

Asymptomatic - week 1

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
FIND 2021	22	0	7	0	Asymptomatic - any	COVID-19 test centre	0.76 [0.56, 0.90]	Not estimable
Bulilete 2021	23	0	11	447	Asymptomatic - contacts	COVID-19 test centre	0.68 [0.49, 0.83]	1.00 [0.99, 1.00]
Siddiqui 2021	16	3	1	449	Asymptomatic - contacts	COVID-19 test centre	0.94 [0.71, 1.00]	0.99 [0.98, 1.00]

Asymptomatic - week 2

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Ford 2021b	17	1	10	370	Asymptomatic - any	COVID-19 test centre	0.63 [0.42, 0.81]	1.00 [0.99, 1.00]
Bulilete 2021	2	0	0	29	Asymptomatic - contacts	COVID-19 test centre	1.00 [0.16, 1.00]	1.00 [0.88, 1.00]

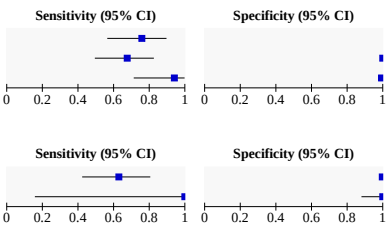
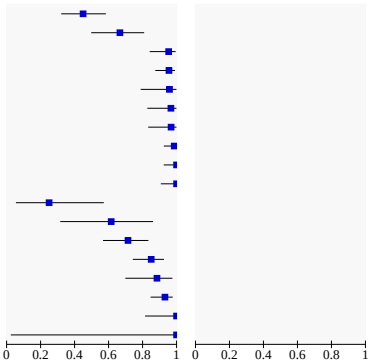


Figure 8. Forest plot of data in subgroups by Ct value

Ct: cycle threshold; DE: Germany; ED: emergency department; HCW: healthcare worker

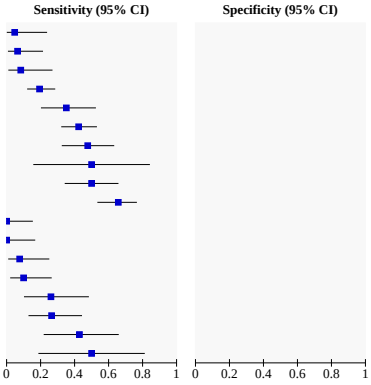
Higher viral load: ‹ 25 Ct

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Thakur 2021	27	0	33	0	Hospital outpatient	Asymptomatic - any	0.45 [0.32, 0.58]	Not estimable
Garcia-Finana 2021	26	0	13	0	Screening - community	Asymptomatic - any	0.67 [0.50, 0.81]	Not estimable
Siddiqui 2021	41	0	2	0	COVID-19 test centre	Asymptomatic - any	0.95 [0.84, 0.99]	Not estimable
Pollock 2021b	64	0	3	0	COVID-19 test centre	Asymptomatic - any	0.96 [0.87, 0.99]	Not estimable
Okoye 2021	23	0	1	0	School/University	Asymptomatic - any	0.96 [0.79, 1.00]	Not estimable
Aranaz-Andrez 2021	29	0	1	0	Hospital inpatient	Asymptomatic - any	0.97 [0.83, 1.00]	Not estimable
Pena 2021	30	0	1	0	COVID-19 test centre	Asymptomatic - any	0.97 [0.83, 1.00]	Not estimable
Pollock 2021a	71	0	1	0	COVID-19 test centre	Asymptomatic - any	0.99 [0.93, 1.00]	Not estimable
Alemany 2021	47	0	0	0	Laboratory-based	Asymptomatic - any	1.00 [0.92, 1.00]	Not estimable
Kiyasu 2021	38	0	0	0	COVID-19 test centre	Asymptomatic - any	1.00 [0.91, 1.00]	Not estimable
Agullo 2021 [B]	3	0	9	0	COVID-19 test centre	Asymptomatic - contacts	0.25 [0.05, 0.57]	Not estimable
Agullo 2021 [A]	8	0	5	0	COVID-19 test centre	Asymptomatic - contacts	0.62 [0.32, 0.86]	Not estimable
Torres 2021a	35	0	14	0	COVID-19 test centre	Asymptomatic - contacts	0.71 [0.57, 0.83]	Not estimable
Takeuchi 2022 [B]	57	0	10	0	COVID-19 test centre	Asymptomatic - contacts	0.85 [0.74, 0.93]	Not estimable
Bulilete 2021	23	0	3	0	COVID-19 test centre	Asymptomatic - contacts	0.88 [0.70, 0.98]	Not estimable
Takeuchi 2022 [A]	68	0	5	0	COVID-19 test centre	Asymptomatic - contacts	0.93 [0.85, 0.98]	Not estimable
Drain 2021	18	0	0	0	COVID-19 test centre	Asymptomatic - contacts	1.00 [0.81, 1.00]	Not estimable
Fenollar 2020	1	0	0	0	Unclear	Asymptomatic - contacts	1.00 [0.03, 1.00]	Not estimable



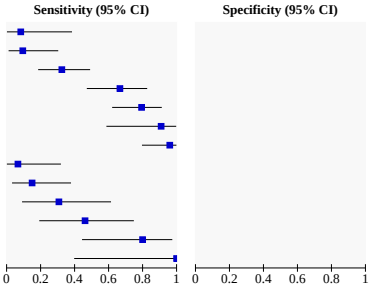
Lower viral load: › 25 Ct

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Okoye 2021	1	0	20	0	School/University	Asymptomatic - any	0.05 [0.00, 0.24]	Not estimable
Garcia-Finana 2021	2	0	29	0	Screening - community	Asymptomatic - any	0.06 [0.01, 0.21]	Not estimable
Thakur 2021	2	0	22	0	Hospital outpatient	Asymptomatic - any	0.08 [0.01, 0.27]	Not estimable
Pollock 2021b	19	0	79	0	COVID-19 test centre	Asymptomatic - any	0.19 [0.12, 0.29]	Not estimable
Kiyasu 2021	13	0	24	0	COVID-19 test centre	Asymptomatic - any	0.35 [0.20, 0.53]	Not estimable
Pollock 2021a	39	0	53	0	COVID-19 test centre	Asymptomatic - any	0.42 [0.32, 0.53]	Not estimable
Siddiqui 2021	21	0	23	0	COVID-19 test centre	Asymptomatic - any	0.48 [0.32, 0.63]	Not estimable
Aranaz-Andrez 2021	4	0	4	0	Hospital inpatient	Asymptomatic - any	0.50 [0.16, 0.84]	Not estimable
Pena 2021	21	0	21	0	COVID-19 test centre	Asymptomatic - any	0.50 [0.34, 0.66]	Not estimable
Alemany 2021	46	0	24	0	Laboratory-based	Asymptomatic - any	0.66 [0.53, 0.77]	Not estimable
Agullo 2021 [A]	0	0	22	0	COVID-19 test centre	Asymptomatic - contacts	0.00 [0.00, 0.15]	Not estimable
Agullo 2021 [B]	0	0	20	0	COVID-19 test centre	Asymptomatic - contacts	0.00 [0.00, 0.17]	Not estimable
Takeuchi 2022 [B]	2	0	24	0	COVID-19 test centre	Asymptomatic - contacts	0.08 [0.01, 0.25]	Not estimable
Torres 2021a	3	0	27	0	COVID-19 test centre	Asymptomatic - contacts	0.10 [0.02, 0.27]	Not estimable
Bulilete 2021	6	0	17	0	COVID-19 test centre	Asymptomatic - contacts	0.26 [0.10, 0.48]	Not estimable
Takeuchi 2022 [A]	9	0	25	0	COVID-19 test centre	Asymptomatic - contacts	0.26 [0.13, 0.44]	Not estimable
Fenollar 2020	9	0	12	0	Unclear	Asymptomatic - contacts	0.43 [0.22, 0.66]	Not estimable
Drain 2021	5	0	5	0	COVID-19 test centre	Asymptomatic - contacts	0.50 [0.19, 0.81]	Not estimable



Subgroup: 25-30 Ct

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Garcia-Finana 2021	1	0	11	0	Screening - community	Asymptomatic - any	0.08 [0.00, 0.38]	Not estimable
Thakur 2021	2	0	19	0	Hospital outpatient	Asymptomatic - any	0.10 [0.01, 0.30]	Not estimable
Pollock 2021b	13	0	27	0	COVID-19 test centre	Asymptomatic - any	0.33 [0.19, 0.49]	Not estimable
Pena 2021	20	0	10	0	COVID-19 test centre	Asymptomatic - any	0.67 [0.47, 0.83]	Not estimable
Pollock 2021a	27	0	7	0	COVID-19 test centre	Asymptomatic - any	0.79 [0.62, 0.91]	Not estimable
Kiyasu 2021	10	0	1	0	COVID-19 test centre	Asymptomatic - any	0.91 [0.59, 1.00]	Not estimable
Alemany 2021	24	0	1	0	Laboratory-based	Asymptomatic - any	0.96 [0.80, 1.00]	Not estimable
Takeuchi 2022 [B]	1	0	14	0	COVID-19 test centre	Asymptomatic - contacts	0.07 [0.00, 0.32]	Not estimable
Torres 2021a	3	0	17	0	COVID-19 test centre	Asymptomatic - contacts	0.15 [0.03, 0.38]	Not estimable
Bulilete 2021	4	0	9	0	COVID-19 test centre	Asymptomatic - contacts	0.31 [0.09, 0.61]	Not estimable
Takeuchi 2022 [A]	6	0	7	0	COVID-19 test centre	Asymptomatic - contacts	0.46 [0.19, 0.75]	Not estimable
Fenollar 2020	8	0	2	0	Unclear	Asymptomatic - contacts	0.80 [0.44, 0.97]	Not estimable
Drain 2021	4	0	0	0	COVID-19 test centre	Asymptomatic - contacts	1.00 [0.40, 1.00]	Not estimable



Higher viral load: ‹ 30 Ct

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Thakur 2021	29	0	52	0	Hospital outpatient	Asymptomatic - any	0.36 [0.25, 0.47]	Not estimable
Reichert 2021	7	0	7	0	ED/Urgent care	Asymptomatic - any	0.50 [0.23, 0.77]	Not estimable
Garcia-Finana 2021	27	0	24	0	Screening - community	Asymptomatic - any	0.53 [0.38, 0.67]	Not estimable
Mungomklang 2021	29	0	21	0	Screening - community	Asymptomatic - any	0.58 [0.43, 0.72]	Not estimable
Okoye 2021	24	0	12	0	School/University	Asymptomatic - any	0.67 [0.49, 0.81]	Not estimable
Baro 2021 [E]	21	0	9	0	Screening - community	Asymptomatic - any	0.70 [0.51, 0.85]	Not estimable
Pollock 2021b	77	0	30	0	COVID-19 test centre	Asymptomatic - any	0.72 [0.62, 0.80]	Not estimable
Baro 2021 [A]	23	0	7	0	Screening - community	Asymptomatic - any	0.77 [0.58, 0.90]	Not estimable
Pena 2021	50	0	11	0	Screening - community	Asymptomatic - any	0.82 [0.70, 0.91]	Not estimable
Baro 2021 [C]	25	0	5	0	Screening - community	Asymptomatic - any	0.83 [0.65, 0.94]	Not estimable
Baro 2021 [D]	25	0	5	0	Screening - community	Asymptomatic - any	0.83 [0.65, 0.94]	Not estimable
Harris 2021	6	0	1	0	School/University	Asymptomatic - any	0.86 [0.42, 1.00]	Not estimable
Baro 2021 [B]	26	0	4	0	Screening - community	Asymptomatic - any	0.87 [0.69, 0.96]	Not estimable
Pollock 2021a	98	0	8	0	COVID-19 test centre	Asymptomatic - any	0.92 [0.86, 0.97]	Not estimable
Kiyasu 2021	48	0	1	0	COVID-19 test centre	Asymptomatic - any	0.98 [0.89, 1.00]	Not estimable
Alemany 2021	71	0	1	0	Laboratory-based	Asymptomatic - any	0.99 [0.93, 1.00]	Not estimable
Agullo 2021 [B]	3	0	17	0	COVID-19 test centre	Asymptomatic - contacts	0.15 [0.03, 0.38]	Not estimable
Agullo 2021 [A]	8	0	15	0	COVID-19 test centre	Asymptomatic - contacts	0.35 [0.16, 0.57]	Not estimable
Torres 2021a	38	0	31	0	COVID-19 test centre	Asymptomatic - contacts	0.55 [0.43, 0.67]	Not estimable
Bulilete 2021	27	0	12	0	COVID-19 test centre	Asymptomatic - contacts	0.69 [0.52, 0.83]	Not estimable
Takeuchi 2022 [B]	58	0	24	0	COVID-19 test centre	Asymptomatic - contacts	0.71 [0.60, 0.80]	Not estimable
Fenollar 2020	9	0	2	0	Unclear	Asymptomatic - contacts	0.82 [0.48, 0.98]	Not estimable
Takeuchi 2022 [A]	74	0	16	0	COVID-19 test centre	Asymptomatic - contacts	0.82 [0.73, 0.89]	Not estimable

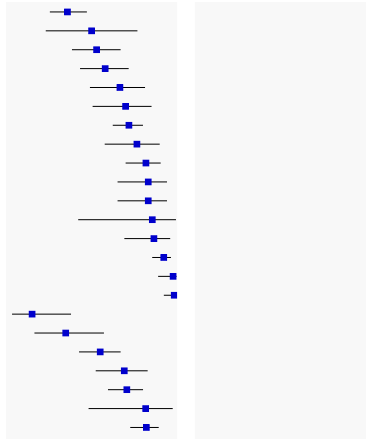
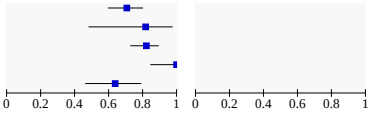


Figure 8. (Continued)

Takeuchi 2022 [B]	58	0	24	0	COVID-19 test centre	Asymptomatic - contacts	0.71 [0.60, 0.80]	Not estimable
Fenollar 2020	9	0	2	0	Unclear	Asymptomatic - contacts	0.82 [0.48, 0.98]	Not estimable
Takeuchi 2022 [A]	74	0	16	0	COVID-19 test centre	Asymptomatic - contacts	0.82 [0.73, 0.89]	Not estimable
Drain 2021	22	0	0	0	COVID-19 test centre	Asymptomatic - contacts	1.00 [0.85, 1.00]	Not estimable
Jakobsen 2021b	23	0	13	0	COVID-19 test centre	Asymptomatic - no details	0.64 [0.46, 0.79]	Not estimable



Lower viral load: › 30 Ct

Study	TP	FP	FN	TN	Setting	Symptom status	Sensitivity (95% CI)	Specificity (95% CI)
Harris 2021	0	0	12	0	School/University	Asymptomatic - any	0.00 [0.00, 0.26]	Not estimable
Okoye 2021	0	0	9	0	School/University	Asymptomatic - any	0.00 [0.00, 0.34]	Not estimable
Reichert 2021	0	0	4	0	ED/Urgent care	Asymptomatic - any	0.00 [0.00, 0.60]	Not estimable
Thakur 2021	0	0	3	0	Hospital outpatient	Asymptomatic - any	0.00 [0.00, 0.71]	Not estimable
Garcia-Finana 2021	1	0	18	0	Screening - community	Asymptomatic - any	0.05 [0.00, 0.26]	Not estimable
Pena 2021	1	0	11	0	COVID-19 test centre	Asymptomatic - any	0.08 [0.00, 0.38]	Not estimable
Pollock 2021b	6	0	52	0	COVID-19 test centre	Asymptomatic - any	0.10 [0.04, 0.21]	Not estimable
Baro 2021 [E]	8	0	63	0	Screening - community	Asymptomatic - any	0.11 [0.05, 0.21]	Not estimable
Kiyasu 2021	3	0	23	0	COVID-19 test centre	Asymptomatic - any	0.12 [0.02, 0.30]	Not estimable
Pollock 2021a	12	0	65	0	COVID-19 test centre	Asymptomatic - any	0.16 [0.08, 0.26]	Not estimable
Baro 2021 [A]	16	0	55	0	Screening - community	Asymptomatic - any	0.23 [0.13, 0.34]	Not estimable
Baro 2021 [C]	19	0	52	0	Screening - community	Asymptomatic - any	0.27 [0.17, 0.39]	Not estimable
Baro 2021 [D]	21	0	50	0	Screening - community	Asymptomatic - any	0.30 [0.19, 0.42]	Not estimable
Mungomklang 2021	6	0	13	0	Screening - community	Asymptomatic - any	0.32 [0.13, 0.57]	Not estimable
Baro 2021 [B]	26	0	45	0	Screening - community	Asymptomatic - any	0.37 [0.25, 0.49]	Not estimable
Alemany 2021	22	0	23	0	Laboratory-based	Asymptomatic - any	0.49 [0.34, 0.64]	Not estimable
Agullo 2021 [A]	0	0	12	0	COVID-19 test centre	Asymptomatic - contacts	0.00 [0.00, 0.26]	Not estimable
Agullo 2021 [B]	0	0	12	0	COVID-19 test centre	Asymptomatic - contacts	0.00 [0.00, 0.26]	Not estimable
Torres 2021a	0	0	10	0	COVID-19 test centre	Asymptomatic - contacts	0.00 [0.00, 0.31]	Not estimable
Fenollar 2020	1	0	10	0	Unclear	Asymptomatic - contacts	0.09 [0.00, 0.41]	Not estimable
Takeuchi 2022 [B]	1	0	10	0	COVID-19 test centre	Asymptomatic - contacts	0.09 [0.00, 0.41]	Not estimable
Takeuchi 2022 [A]	3	0	18	0	COVID-19 test centre	Asymptomatic - contacts	0.14 [0.03, 0.36]	Not estimable
Drain 2021	1	0	5	0	COVID-19 test centre	Asymptomatic - contacts	0.17 [0.00, 0.64]	Not estimable
Bulilete 2021	2	0	8	0	COVID-19 test centre	Asymptomatic - contacts	0.20 [0.03, 0.56]	Not estimable
Jakobsen 2021b	9	0	21	0	COVID-19 test centre	Asymptomatic - no details	0.30 [0.15, 0.49]	Not estimable

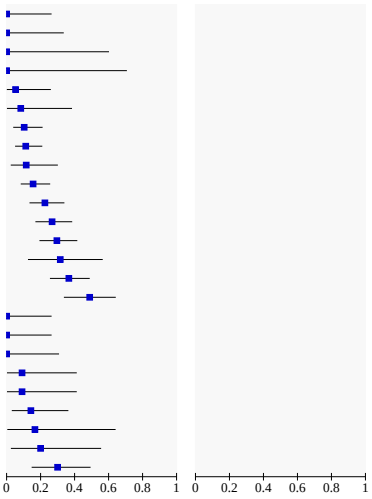


Figure 9. Forest plot of data for within-study comparison of data for children and adults AN: anterior nasal; nos: not otherwise specified

Children (asymptomatic data)

Study	TP	FP	FN	TN	Sample type	Symptom status	Age	Sensitivity (95% CI)	Specificity (95% CI)
Kriemler 2021	0	5	1	562	Buccal	Asymptomatic - any	Paediatric <18 y	0.00 [0.00, 0.97]	0.99 [0.98, 1.00]
Pollock 2021a	70	7	37	715	Nasal (AN)	Asymptomatic - any	Paediatric <18 y	0.65 [0.56, 0.74]	0.99 [0.98, 1.00]
Pollock 2021b	26	7	20	200	Nasal (AN)	Mainly asymptomatic	Paediatric <18 y	0.57 [0.41, 0.71]	0.97 [0.93, 0.99]
Prince-Guerra 2021	9	1	13	212	Nasal (AN)	Mainly asymptomatic	Paediatric <18 y	0.41 [0.21, 0.64]	1.00 [0.97, 1.00]
Almendares 2021	9	1	13	213	Nasal (AN)	Mainly asymptomatic	Paediatric <18 y	0.41 [0.21, 0.64]	1.00 [0.97, 1.00]
Blanchard 2021	21	7	32	7242	Nasal (nos)	Mainly asymptomatic	Paediatric <16 y	0.40 [0.26, 0.54]	1.00 [1.00, 1.00]

Adult (within-study comparison)

Study	TP	FP	FN	TN	Sample type	Symptom status	Age	Sensitivity (95% CI)	Specificity (95% CI)
Kriemler 2021	0	1	0	61	Buccal	Asymptomatic - any	Adult	Not estimable	0.98 [0.91, 1.00]
Pollock 2021a	40	4	17	913	Nasal (AN)	Asymptomatic - any	Adult	0.70 [0.57, 0.82]	1.00 [0.99, 1.00]
Pollock 2021b	109	14	79	1043	Nasal (AN)	Mainly asymptomatic	Adult	0.58 [0.51, 0.65]	0.99 [0.98, 0.99]
Prince-Guerra 2021	148	3	129	2903	Nasal (AN)	Mainly asymptomatic	Adult	0.53 [0.47, 0.59]	1.00 [1.00, 1.00]
Almendares 2021	148	3	129	2903	Nasal (AN)	Mainly asymptomatic	Adult	0.53 [0.47, 0.59]	1.00 [1.00, 1.00]
Blanchard 2021	1	1	1	898	Nasal (nos)	Mainly asymptomatic	Adult	0.50 [0.01, 0.99]	1.00 [0.99, 1.00]

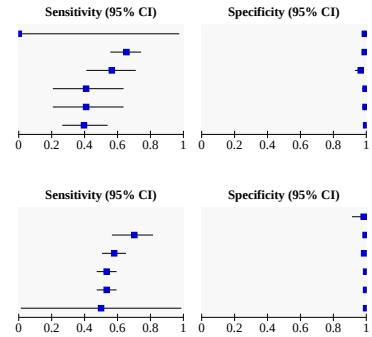


Figure 10. Forest plot of data by sample site AN: anterior nasal; DE: Germany; ED: emergency department; HCW: healthcare worker; NMT: nasal mid-turbinate; nos: not otherwise specified; NP: nasopharyngeal; OP: oropharyngeal; TA: throat aspirate; TS: throat swab; TW: throat wash

Study	TP	FP	FN	TN	Sample group	Swab testing	Sample type	Collection	Reference sample	Sensitivity (95% CI)	Specificity (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
Chiu 2021	32	18	6	22938	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; Nasal+OP	0.84 [0.69, 0.94]	1.00 [1.00, 1.00]		
Prince-Guerra 2021	44	4	79	2465	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.36 [0.27, 0.45]	1.00 [1.00, 1.00]		
Brihn 2021	49	8	32	1643	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.60 [0.49, 0.71]	1.00 [0.99, 1.00]		
Siddiqui 2021	62	7	25	5105	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.71 [0.61, 0.80]	1.00 [1.00, 1.00]		
Leli 2021	26	20	28	303	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.48 [0.34, 0.62]	0.94 [0.91, 0.96]		
Almendares 2021	21	3	32	1912	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.40 [0.26, 0.54]	1.00 [1.00, 1.00]		
Takeuchi 2022 [B]	60	0	40	311	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; NP	0.60 [0.50, 0.70]	1.00 [0.99, 1.00]		
Sun 2022	25	10	2	719	Nasal (all)	Direct	Nasal (AN)	HCW	Paired; same as index	0.93 [0.76, 0.99]	0.99 [0.97, 0.99]		
Ford 2021a	10	16	11	836	Nasal (all)	Direct	Nasal (NMT)	HCW	Paired; same as index	0.48 [0.26, 0.70]	0.98 [0.97, 0.99]		
Agullo 2021 [A]	8	0	27	230	Nasal (all)	Direct	Nasal (nos)	HCW	Paired; NP	0.23 [0.10, 0.40]	1.00 [0.98, 1.00]		
Boyle 2021	0	0	2	88	Nasal + OP	Direct	Nasal+OP	HCW	Paired; same as index	0.00 [0.00, 0.84]	1.00 [0.96, 1.00]		
Venekamp 2022(e)	3	0	8	277	Nasal + OP	Direct	Nasal+OP	HCW	Paired; same as index	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]		
Venekamp 2022(c)	29	0	17	689	Nasal + OP	Direct	Nasal+OP	HCW	Paired; same as index	0.63 [0.48, 0.77]	1.00 [0.99, 1.00]		
Venekamp 2022(a)	33	1	26	682	Nasal + OP	Direct	Nasal+OP	HCW	Paired; same as index	0.56 [0.42, 0.69]	1.00 [0.99, 1.00]		
Venekamp 2022(d)	19	0	15	477	Includes NP (all)	Direct	NP alone	HCW	Paired; Nasal+OP	0.56 [0.38, 0.73]	1.00 [0.99, 1.00]		
Konstantinus 2021	4	0	3	55	Includes NP (all)	Direct	NP alone	HCW	Paired; NP	0.57 [0.18, 0.90]	1.00 [0.94, 1.00]		
Takeuchi 2022 [A]	77	3	34	760	Includes NP (all)	Direct	NP alone	HCW	Paired; NP	0.69 [0.60, 0.78]	1.00 [0.99, 1.00]		
Venekamp 2022(b)	34	1	29	594	Includes NP (all)	Direct	NP alone	HCW	Paired; NP+OP	0.54 [0.41, 0.67]	1.00 [0.99, 1.00]		
Reichert 2021	7	1	11	347	Includes NP (all)	Direct	NP alone	HCW	Paired; NP+OP	0.39 [0.17, 0.64]	1.00 [0.98, 1.00]		
Fernandez-Montero 2021	31	7	13	2465	Includes NP (all)	Direct	NP alone	HCW	Paired; OP	0.70 [0.55, 0.83]	1.00 [0.99, 1.00]		
Pena 2021	51	3	22	766	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.70 [0.58, 0.80]	1.00 [0.99, 1.00]		
Bulilete 2021	30	0	23	632	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.57 [0.42, 0.70]	1.00 [0.99, 1.00]		
Linares 2020	5	0	5	62	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.50 [0.19, 0.81]	1.00 [0.94, 1.00]		
Masia 2021	13	0	26	253	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.33 [0.19, 0.50]	1.00 [0.99, 1.00]		
Rottenstreich 2021	5	0	4	1317	Includes NP (all)	Not specified	NP alone	HCW	Paired; same as index	0.56 [0.21, 0.86]	1.00 [1.00, 1.00]		
Torres 2021a	38	0	41	555	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.48 [0.37, 0.60]	1.00 [0.99, 1.00]		
Torres 2021b	15	0	10	67	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.60 [0.39, 0.79]	1.00 [0.95, 1.00]		
L'Huillier 2021	13	0	17	259	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.43 [0.25, 0.63]	1.00 [0.99, 1.00]		
Abdul-Mumin 2021	13	1	6	38	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.68 [0.43, 0.87]	0.97 [0.87, 1.00]		
Aranaz-Andrez 2021	25	1	5	510	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.83 [0.65, 0.94]	1.00 [0.99, 1.00]		
Caruana 2021b	2	2	5	107	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.29 [0.04, 0.71]	0.98 [0.94, 1.00]		
Menchinelli 2021a	18	48	25	1724	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.42 [0.27, 0.58]	0.97 [0.96, 0.98]		
Merino-Amador 2021	23	0	2	15	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.92 [0.74, 0.99]	1.00 [0.78, 1.00]		
Homza 2021a(b)	6	0	7	74	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.46 [0.19, 0.75]	1.00 [0.95, 1.00]		
Homza 2021a(e)	4	5	13	93	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.24 [0.07, 0.50]	0.95 [0.88, 0.98]		
Homza 2021a(d)	4	0	4	64	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.50 [0.16, 0.84]	1.00 [0.94, 1.00]		
Smith 2021b	33	4	9	1160	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.79 [0.63, 0.90]	1.00 [0.99, 1.00]		
Holzner 2021	31	3	19	783	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.62 [0.47, 0.75]	1.00 [0.99, 1.00]		
Homza 2021a(a)	8	5	12	154	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.40 [0.19, 0.64]	0.97 [0.93, 0.99]		
Homza 2021a(c)	9	31	10	41	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.47 [0.24, 0.71]	0.57 [0.45, 0.69]		
Homza 2021b	13	5	15	237	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.46 [0.28, 0.66]	0.98 [0.95, 0.99]		
Ifko 2021	9	7	0	139	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	1.00 [0.66, 1.00]	0.95 [0.90, 0.98]		
Fitoussi 2021	45	2	23	652	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.66 [0.54, 0.77]	1.00 [0.99, 1.00]		
Jegerlehner 2021	11	1	14	325	Includes NP (all)	VTM	NP alone	HCW	Paired; same as index	0.44 [0.24, 0.65]	1.00 [0.98, 1.00]		
Kanaujia 2021	23	0	18	72	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.56 [0.40, 0.72]	1.00 [0.95, 1.00]		
Le Goff 2021	24	8	8	782	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.75 [0.57, 0.89]	0.99 [0.98, 1.00]		
Klein 2021 [B]	7	0	1	147	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.88 [0.47, 1.00]	1.00 [0.98, 1.00]		
Roger 2021	8	16	20	3445	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.29 [0.13, 0.49]	1.00 [0.99, 1.00]		
Von Ahnen 2021	12	0	1	906	Includes NP (all)	Not specified	NP alone	HCW	Paired; same as index	0.92 [0.64, 1.00]	1.00 [1.00, 1.00]		
Thirion-Romero 2021	15	1	42	88	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.26 [0.16, 0.40]	0.99 [0.94, 1.00]		
Turcato 2021	65	11	38	2594	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.63 [0.53, 0.72]	1.00 [0.99, 1.00]		
FIND 2021	102	2	28	854	Includes NP (all)	Direct	NP alone	HCW	Paired; same as index	0.78 [0.70, 0.85]	1.00 [0.99, 1.00]		
Baro 2021 [A]	39	1	62	184	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.39 [0.29, 0.49]	0.99 [0.97, 1.00]		
Baro 2021 [B]	52	3	49	182	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.51 [0.41, 0.62]	0.98 [0.95, 1.00]		
Baro 2021 [C]	44	7	57	178	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.44 [0.34, 0.54]	0.96 [0.92, 0.98]		
Baro 2021 [D]	46	20	55	165	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.46 [0.36, 0.56]	0.89 [0.84, 0.93]		
Baro 2021 [E]	29	4	72	181	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.29 [0.20, 0.39]	0.98 [0.95, 0.99]		
Farfour 2021	0	0	3	189	Includes NP (all)	VTM	NP alone	HCW	Same sample used	0.00 [0.00, 0.71]	1.00 [0.98, 1.00]		
Revollo 2021 [A]	0	0	0	465	Includes NP (all)	Direct	NP alone	HCW	Same sample used	Not estimable	1.00 [0.99, 1.00]		
Revollo 2021 [B]	2	0	0	493	Includes NP (all)	Direct	NP alone	HCW	Same sample used	1.00 [0.16, 1.00]	1.00 [0.99, 1.00]		
Quentin 2022	3	0	8	501	Other	Direct	NPA	HCW	Same sample used	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]		
Pilarowski 2020a	83	2	19	2298	Nasal (all)	Direct	Nasal (AN)	Laboratory scientist	Paired; same as index	0.81 [0.72, 0.88]	1.00 [1.00, 1.00]		
Pilarowski 2021	15	9	11	836	Nasal (all)	Direct	Nasal (AN)	Laboratory scientist	Paired; same as index	0.58 [0.37, 0.77]	0.99 [0.98, 1.00]		
Schrom 2022	64	2	58	310	Nasal (all)	Direct	Nasal (AN)	Laboratory scientist	Paired; same as index	0.52 [0.43, 0.62]	0.99 [0.98, 1.00]		
Aleem 2022	6	1	14	328	Includes NP (all)	Direct	NP alone	Laboratory scientist	Paired; same as index	0.30 [0.12, 0.54]	1.00 [0.98, 1.00]		
Cubas-Atienzar 2021a	19	0	5	47	Includes NP (some)	Direct	Mixed	Mixed	Paired; same as index	0.79 [0.58, 0.93]	1.00 [0.92, 1.00]		
Allan-Blitz 2021	420	83	538	7646	Nasal (all)	Direct	Nasal (AN)	Mixed	Paired; NP, OP, AN	0.44 [0.41, 0.47]	0.99 [0.99, 0.99]		
Pray 2021	7	14	10	840	Nasal (all)	Direct	Nasal (NMT)	Mixed	Paired; same as index	0.41 [0.18, 0.67]	0.98 [0.97, 0.99]		
Zobrist 2022 [A]	12	0	30	0	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; NP	0.29 [0.16, 0.45]	Not estimable		
Stokes 2021	0	1	6	990	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; NP	0.00 [0.00, 0.46]	1.00 [0.99, 1.00]		
Zobrist 2022 [C]	10	0	32	0	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; NP	0.24 [0.12, 0.39]	Not estimable		
Muthamia 2022	16	1	3	127	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; OP	0.84 [0.60, 0.97]	0.99 [0.96, 1.00]		
James 2021	66	3	62	2093	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; same as index	0.52 [0.43, 0.60]	1.00 [1.00, 1.00]		
Drain 2021	23	0	5	194	Nasal (all)	Direct	Nasal (AN)	Not specified	Paired; same as index	0.82 [0.63, 0.94]	1.00 [0.98, 1.00]		
Alemany 2021	93	5	24	365	Nasal (all)	VTM	Nasal (NMT)	Not specified	Same sample used	0.79 [0.71, 0.86]	0.99 [0.97, 1.00]		
Bianco 2021	93	44	8	531	Nasal (all)	Direct	Nasal (nos)	Not specified	Paired; NP	0.92 [0.85, 0.97]	0.92 [0.90, 0.94]		
Burdino 2021	46	0	14	0	Nasal (all)	Not specified	Nasal (nos)	Not specified	Paired; NP	0.77 [0.64, 0.87]	Not estimable		
Fernandez 2022	7	0	2	18	Nasal (all)	Direct	Nasal (nos)	Not specified	Paired; NP	0.78 [0.40, 0.97]	1.00 [0.81, 1.00]		
Garcia-Cardenas 2021	46	5	15	382	Nasal (all)	Direct	Nasal (nos)	Not specified	Paired; NP	0.75 [0.63, 0.86]	0.99 [0.97, 1.00]		
Parada-Ricart 2021	0	9	1	34	Nasal (all)	Direct	Nasal (nos)	Not specified	Paired; same as index	0.00 [0.00, 0.97]	0.79 [0.64, 0.90]		
Salcedo 2021	29	1	6	75	Nasal (all)	Saline	Nasal (nos)	Not specified	Same sample used	0.83 [0.66, 0.93]	0.99 [0.93, 1.00]		
Del Vecchio 2021	9	0	1	0	Not specified	Direct	Not specified	Not specified	Paired; same as index	0.90 [0.55, 1.00]	Not estimable		
Drevinek 2020 [A]	24	0	31	0	Includes NP (all)	Direct	NP alone	Not specified	Paired; NP+OP	0.44 [0.30, 0.58]	Not estimable		
Drevinek 2020 [B]	24	0	31	0	Includes NP (all)	Direct	NP alone	Not specified	Paired; NP+OP	0.44 [0.30, 0.58]	Not estimable		
Gremmels 2021	2	0	1	34	Includes NP (all)	Not specified	NP alone	Not specified	Paired; NP+OP	0.67 [0.09, 0.99]	1.00 [0.90, 1.00]		
Gupta 2021	9	1	4	113	Includes NP (all)	Direct	NP alone	Not specified	Paired; NP+OP	0.69 [0.39, 0.91]	0.99 [0.95, 1.00]		
Pandey 2021	5	2	10	170	Includes NP (all)	Direct	NP alone	Not specified	Paired; NP+OP	0.33 [0.12, 0.62]	0.99 [0.96, 1.00]		
Fenollar 2020	10	7	12	130	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.45 [0.24, 0.68]	0.95 [0.90, 0.98]		
Merino 2021	31	0	0	97	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	1.00 [0.89, 1.00]	1.00 [0.96, 1.00]		
Shrestha 2020	40	0	7	66	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.85 [0.72, 0.94]	1.00 [0.95, 1.00]		
Takeuchi 2021a	25	0	8	382	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.76 [0.58, 0.89]	1.00 [0.99, 1.00]		
Lopera 2022	6	0	44	89	Includes NP (all)	VTM	NP alone	Not specified	Paired; same as index	0.12 [0.05, 0.24]	1.00 [0.96, 1.00]		
Boum 2021	33	0	56	0	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.37 [0.27, 0.48]	Not estimable		
Diez Flecha 2021	26	0	11	6	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.70 [0.53, 0.84]	1.00 [0.54, 1.00]		
Eleftheriou 2021	2	0	7	251	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.22 [0.03, 0.60]	1.00 [0.99, 1.00]		
Kiyasu 2021	51	0	25	997	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.67 [0.55, 0.77]	1.00 [1.00, 1.00]		
Kurihara 2021	30	2	17	491	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.64 [0.49, 0.77]	1.00 [0.99, 1.00]		
Suzuki 2021	13	3	14	295	Includes NP (all)	Direct	NP alone	Not specified	Paired; same as index	0.48 [0.29, 0.68]	0.99 [0.97, 1.00]		
Caruana 2021a [A]	8	0	16	215	Includes NP (all)	VTM	NP alone	Not specified	Same sample used	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]		
Caruana 2021a [B]	8	1	16	214	Includes NP (all)	VTM	NP alone	Not specified	Same sample used	0.33 [0.16, 0.55]	1.00 [0.97, 1.00]		
Caruana 2021a [C]	8	0	16	215	Includes NP (all)	VTM	NP alone	Not specified	Same sample used	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]		
Caruana 2021a [D]	8	0	16	215	Includes NP (all)	VTM	NP alone	Not specified	Same sample used	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]		
Scohy 2020	4	0	10	31	Includes NP (all)	Not specified	NP alone	Not specified	Same sample used	0.29 [0.08, 0.58]	1.00 [0.89, 1.00]		
Qahtani 2021	0	0	0	592	Includes NP (all)	Direct	NP alone	Not specified	Same sample used	Not estimable	1.00 [0.99, 1.00]		
Mungomklang 2021	35	3	38	1024	Includes NP (all)	VTM	NP alone	Not specified	Same sample used	0.48 [0.36, 0.60]	1.00 [0.99, 1.00]		
Cerutti 2020	2	0	3	140	Includes NP (all)	VTM	NP alone	Not specified	Unclear; same sample site	0.40 [0.05, 0.85]	1.00 [0.97, 1.00]		
Halfon 2021	20	0	15	0	Includes NP (all)	Not specified	NP alone	Not specified	Unclear; same sample site	0.57 [0.39, 0.74]	Not estimable		
Kumar 2021b	2	0	10	192	Includes NP (all)	Direct or VTM	NP+OP	Not specified	Same sample used	0.17 [0.02, 0.48]	1.00 [0.98, 1.00]		
Zobrist 2022 [B]	7	0	35	0	Saliva (all)	Direct	Saliva	Not specified	Paired; NP	0.17 [0.07, 0.31]	Not estimable		
Schildgen 2021 [A]	4	1	9	13	Other	Not specified	TS or TW or TA	Not specified	Same sample used	0.31 [0.09, 0.61]	0.93 [0.66, 1.00]		
Schildgen 2021 [B]	5	4	8	10	Other	Not specified	TS or TW or TA	Not specified	Same sample used	0.38 [0.14, 0.68]	0.71 [0.42, 0.92]		
Schildgen 2021 [C]	11	12	2	2	Other	Not specified	TS or TW or TA	Not specified	Same sample used	0.85 [0.55, 0.98]	0.14 [0.02, 0.43]		
Schuit 2021b(b)	7	2	24	454	Nasal (all)	Direct	Nasal (AN)	Self-collected	Paired; Nasal+OP	0.23 [0.10, 0.41]	1.00 [0.98, 1.00]		

Figure 10. (Continued)

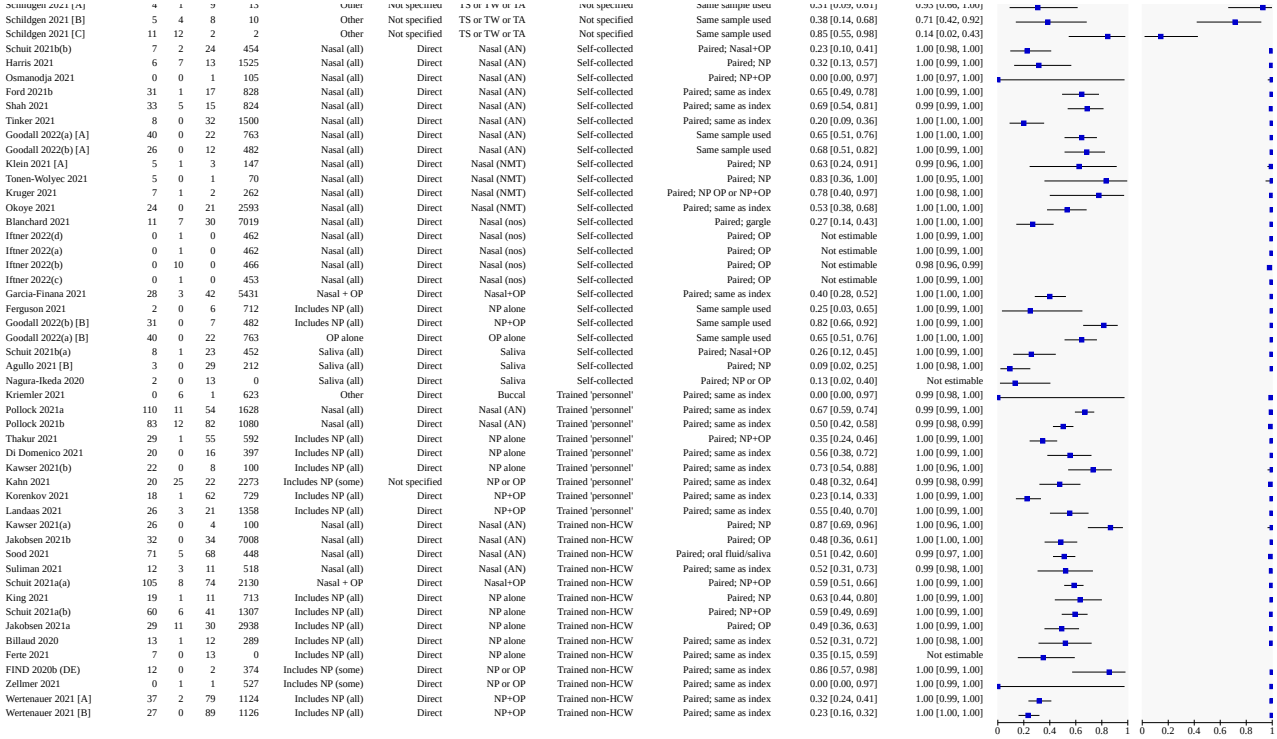
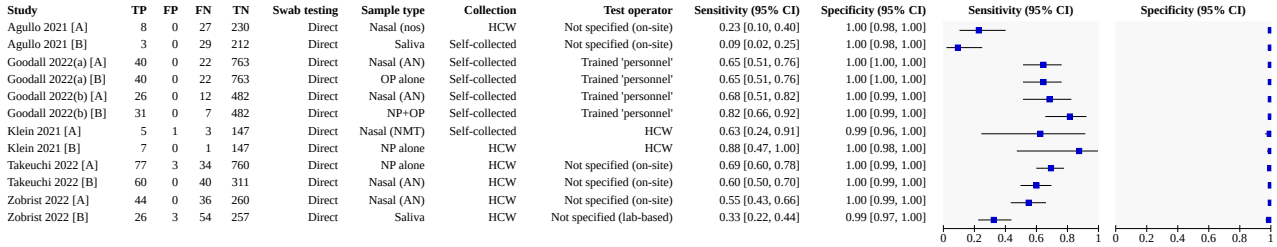


Figure 11. Forest plot of within-study comparisons by sample site, collection or interpretation AN: anterior nasal; HCW: healthcare worker; NMT: nasal mid-turbinate; nos: not otherwise specified; NP: nasopharyngeal; OP: oropharyngeal



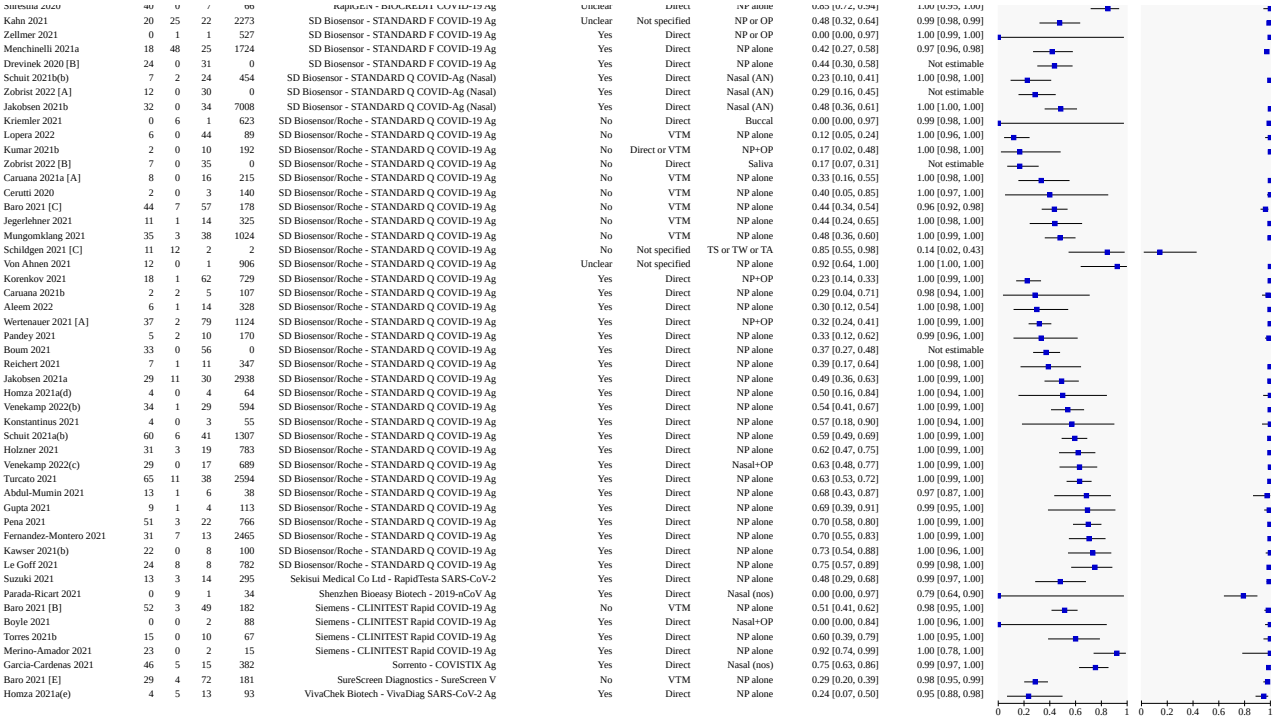
Forest plots and summary results by test brand overall and for sensitivity analyses restricted by studies complying with manufacturer IFUs are presented in Supplementary material 17 (Figure 12) and Supplementary material 16. A forest plot showing within-study comparisons of test brands is also included in Supplementary material 17 (Figure 13).

Figure 12. Forest plot of individual study results in asymptomatic participants by assay Ag: antigen; AN: anterior nasal; DE: Germany; ED: emergency department; HCW: healthcare worker; NMT: nasal mid-turbinate; nos: not

otherwise specified; NP: nasopharyngeal; OP: oropharyngeal; TA: throat aspirate; TS: throat swab; TW: throat wash; VTM: viral transport medium

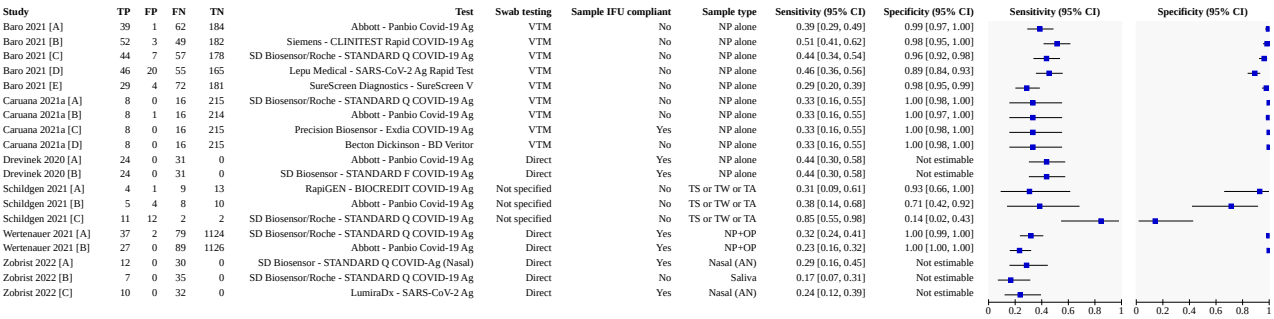
Study	TP	FP	FN	TN	Test	Sample IFU compliant	Swab testing	Sample type	Sensitivity (95% CI)	Specificity (95% CI)
Stokes 2021	0	1	6	990	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.00 [0.00, 0.46]	1.00 [0.99, 1.00]
Tinker 2021	8	0	32	1500	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.20 [0.09, 0.36]	1.00 [1.00, 1.00]
Prince-Guerra 2021	44	4	79	2465	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.36 [0.27, 0.45]	1.00 [1.00, 1.00]
Almendares 2021	21	3	32	1912	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.40 [0.26, 0.54]	1.00 [1.00, 1.00]
Allan-Blitz 2021	420	83	538	7646	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.44 [0.41, 0.47]	0.99 [0.99, 0.99]
Sood 2021	71	5	68	448	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.51 [0.42, 0.60]	0.99 [0.97, 1.00]
James 2021	66	3	62	2093	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.52 [0.43, 0.60]	1.00 [1.00, 1.00]
Schrom 2022	64	2	58	310	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.52 [0.43, 0.62]	0.99 [0.98, 1.00]
Okoye 2021	24	0	21	2593	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (NMT)	0.53 [0.38, 0.68]	1.00 [1.00, 1.00]
Pilarowski 2021	15	9	11	836	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.58 [0.37, 0.77]	0.99 [0.98, 1.00]
King 2021	19	1	11	713	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	NP alone	0.63 [0.44, 0.80]	1.00 [0.99, 1.00]
Ford 2021b	31	1	17	828	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.65 [0.49, 0.78]	1.00 [0.99, 1.00]
Pollock 2021a	110	11	54	1628	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.67 [0.59, 0.74]	0.99 [0.99, 1.00]
Shah 2021	33	5	15	824	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.69 [0.54, 0.81]	0.99 [0.99, 1.00]
Siddiqui 2021	62	7	25	5105	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.71 [0.61, 0.80]	1.00 [1.00, 1.00]
Pilarowski 2020a	83	2	19	2298	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.81 [0.72, 0.88]	1.00 [1.00, 1.00]
Sun 2022	25	10	2	719	Abbott - BinaxNOW COVID-19 Ag card	Yes	Direct	Nasal (AN)	0.93 [0.76, 0.99]	0.99 [0.97, 0.99]
Farfour 2021	0	0	3	189	Abbott - Panbio Covid-19 Ag	No	VTM	NP alone	0.00 [0.00, 0.71]	1.00 [0.98, 1.00]
Agullo 2021 [B]	3	0	29	212	Abbott - Panbio Covid-19 Ag	No	Direct	Saliva	0.09 [0.02, 0.25]	1.00 [0.98, 1.00]
Agullo 2021 [A]	8	0	27	230	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal (nos)	0.23 [0.10, 0.40]	1.00 [0.98, 1.00]
Blanchard 2021	11	7	30	7019	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal (nos)	0.27 [0.14, 0.43]	1.00 [1.00, 1.00]
Venekamp 2022(e)	3	0	8	277	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal+OP	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]
Caruana 2021a [B]	8	1	16	214	Abbott - Panbio Covid-19 Ag	No	VTM	NP alone	0.33 [0.16, 0.55]	1.00 [0.97, 1.00]
Schildgen 2021 [B]	5	4	8	10	Abbott - Panbio Covid-19 Ag	No	Not specified	TS or TW or TA	0.38 [0.14, 0.68]	0.71 [0.42, 0.92]
Baro 2021 [A]	39	1	62	184	Abbott - Panbio Covid-19 Ag	No	VTM	NP alone	0.39 [0.29, 0.49]	0.99 [0.97, 1.00]
Di Domenico 2021	20	0	16	397	Abbott - Panbio Covid-19 Ag	No	Direct	NP alone	0.56 [0.38, 0.72]	1.00 [0.99, 1.00]
Klein 2021 [A]	5	1	3	147	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal (NMT)	0.63 [0.24, 0.91]	0.99 [0.96, 1.00]
Goodall 2022(a) [B]	40	0	22	763	Abbott - Panbio Covid-19 Ag	No	Direct	OP alone	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Goodall 2022(a) [A]	40	0	22	763	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal (AN)	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Goodall 2022(b) [A]	26	0	12	482	Abbott - Panbio Covid-19 Ag	No	Direct	Nasal (AN)	0.68 [0.51, 0.82]	1.00 [0.99, 1.00]
Alemany 2021	93	5	24	365	Abbott - Panbio Covid-19 Ag	No	VTM	Nasal (NMT)	0.79 [0.71, 0.86]	0.99 [0.97, 1.00]
Linares 2020	5	0	5	62	Abbott - Panbio Covid-19 Ag	Unclear	Direct	NP alone	0.50 [0.19, 0.81]	1.00 [0.94, 1.00]
Halfon 2021	20	0	15	0	Abbott - Panbio Covid-19 Ag	Unclear	Not specified	NP alone	0.57 [0.39, 0.74]	Not estimable
Gremmels 2021	2	0	1	34	Abbott - Panbio Covid-19 Ag	Unclear	Not specified	NP alone	0.67 [0.09, 0.99]	1.00 [0.90, 1.00]
Del Vecchio 2021	9	0	1	0	Abbott - Panbio Covid-19 Ag	Unclear	Direct	Not specified	0.90 [0.55, 1.00]	Not estimable
Masia 2021	13	0	26	253	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.33 [0.19, 0.50]	1.00 [0.99, 1.00]
L'Huillier 2021	13	0	17	259	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.43 [0.25, 0.63]	1.00 [0.99, 1.00]
Drevinek 2020 [A]	24	0	31	0	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.44 [0.30, 0.58]	Not estimable
Fenollar 2020	10	7	12	130	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.45 [0.24, 0.68]	0.95 [0.90, 0.98]
Torres 2021a	38	0	41	555	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.48 [0.37, 0.60]	1.00 [0.99, 1.00]
Billaud 2020	13	1	12	289	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.52 [0.31, 0.72]	1.00 [0.98, 1.00]
Bulilete 2021	30	0	23	632	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.57 [0.42, 0.70]	1.00 [0.99, 1.00]
FIND 2020b (DE)	12	0	2	374	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP or OP	0.86 [0.57, 0.98]	1.00 [0.99, 1.00]
Merino 2021	31	0	0	97	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	1.00 [0.89, 1.00]	1.00 [0.96, 1.00]
Qahtani 2021	0	0	0	592	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	Not estimable	1.00 [0.99, 1.00]
Eleftheriou 2021	2	0	7	251	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.22 [0.03, 0.60]	1.00 [0.99, 1.00]
Wertenauer 2021 [B]	27	0	89	1126	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP+OP	0.23 [0.16, 0.32]	1.00 [1.00, 1.00]
Thirion-Romero 2021	15	1	42	88	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.26 [0.16, 0.40]	0.99 [0.94, 1.00]
Roger 2021	8	16	20	3445	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.29 [0.13, 0.49]	1.00 [0.99, 1.00]
Ferte 2021	7	0	13	0	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.35 [0.15, 0.59]	Not estimable
Landaas 2021	26	3	21	1358	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP+OP	0.55 [0.40, 0.70]	1.00 [0.99, 1.00]
Venekamp 2022(d)	19	0	15	477	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.56 [0.38, 0.73]	1.00 [0.99, 1.00]
Diez Flecha 2021	26	0	11	6	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.70 [0.53, 0.84]	1.00 [0.54, 1.00]
Goodall 2022(b) [B]	31	0	7	482	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP+OP	0.82 [0.66, 0.92]	1.00 [0.99, 1.00]
Aranaz-Andrez 2021	25	1	5	510	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.83 [0.65, 0.94]	1.00 [0.99, 1.00]
Klein 2021 [B]	7	0	1	147	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	0.88 [0.47, 1.00]	1.00 [0.98, 1.00]
Revollo 2021 [A]	0	0	0	465	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	Not estimable	1.00 [0.99, 1.00]
Revollo 2021 [B]	2	0	0	493	Abbott - Panbio Covid-19 Ag	Yes	Direct	NP alone	1.00 [0.16, 1.00]	1.00 [0.99, 1.00]
Pollock 2021b	83	12	82	1080	Access Bio - CareStart Covid-19 Ag	Yes	Direct	Nasal (AN)	0.50 [0.42, 0.58]	0.99 [0.98, 0.99]
Suliman 2021	12	3	11	518	Access Bio - CareStart Covid-19 Ag	Yes	Direct	Nasal (AN)	0.52 [0.31, 0.73]	0.99 [0.98, 1.00]
Iftner 2022(a)	0	1	0	462	Anbio Biotech - COVID-19 Ag	Yes	Direct	Nasal (nos)	Not estimable	1.00 [0.99, 1.00]
Homza 2021a(a)	8	5	12	154	Assure Tech - Ecotest	Yes	Direct	NP alone	0.40 [0.19, 0.64]	0.97 [0.93, 0.99]
Homza 2021b	13	5	15	237	Assure Tech - Ecotest	Yes	Direct	NP alone	0.46 [0.28, 0.66]	0.98 [0.95, 0.99]
Caruana 2021a [D]	8	0	16	215	Becton Dickinson - BD Veritor	No	VTM	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Schuit 2021a(a)	105	8	74	2130	Becton Dickinson - BD Veritor	No	Direct	Nasal+OP	0.59 [0.51, 0.66]	1.00 [0.99, 1.00]
Venekamp 2022(a)	33	1	26	682	Becton Dickinson - BD Veritor	Yes	Direct	Nasal+OP	0.56 [0.42, 0.69]	1.00 [0.99, 1.00]
Muthamia 2022	16	1	3	127	Becton Dickinson - BD Veritor	Yes	Direct	Nasal (AN)	0.84 [0.60, 0.97]	0.99 [0.96, 1.00]
Kawser 2021(a)	26	0	4	100	Becton Dickinson - BD Veritor	Yes	Direct	Nasal (AN)	0.87 [0.69, 0.96]	1.00 [0.96, 1.00]
Iftner 2022(c)	0	1	0	453	Beijing Hotgen - COVID-19 Ag Home	Yes	Direct	Nasal (nos)	Not estimable	1.00 [0.99, 1.00]
Rottenstreich 2021	5	0	4	1317	BIONOTE - NowCheck COVID-19 Ag	Unclear	Not specified	NP alone	0.56 [0.21, 0.86]	1.00 [1.00, 1.00]
Quentin 2022	3	0	8	501	BioSpeedia - BioSpeedia Ag	Yes	Direct	NPA	0.27 [0.06, 0.61]	1.00 [0.99, 1.00]
Fitoussi 2021	45	2	23	652	Biosynex - Biosynex COVID-19 Ag BSS	Yes	Direct	NP alone	0.66 [0.54, 0.77]	1.00 [0.99, 1.00]
Tonen-Wolyec 2021	5	0	1	70	Biosynex - Biosynex COVID-19 Ag BSS	Yes	Direct	Nasal (NMT)	0.83 [0.36, 1.00]	1.00 [0.95, 1.00]
Scohy 2020	4	0	10	31	Coris Bioconcept - COVID-19 Ag Respi-Strip	Yes	Not specified	NP alone	0.29 [0.08, 0.58]	1.00 [0.89, 1.00]
Kanaujia 2021	23	0	18	72	Coris Bioconcept - COVID-19 Ag Respi-Strip	Yes	Direct	NP alone	0.56 [0.40, 0.72]	1.00 [0.95, 1.00]
Takeuchi 2022 [B]	60	0	40	311	Denka Co - QuickNavi COVID-19 Ag	Yes	Direct	Nasal (AN)	0.60 [0.50, 0.70]	1.00 [0.99, 1.00]
Kiyasu 2021	51	0	25	997	Denka Co - QuickNavi COVID-19 Ag	Yes	Direct	NP alone	0.67 [0.55, 0.77]	1.00 [1.00, 1.00]
Takeuchi 2022 [A]	77	3	34	760	Denka Co - QuickNavi COVID-19 Ag	Yes	Direct	NP alone	0.69 [0.60, 0.78]	1.00 [0.99, 1.00]
Takeuchi 2021a	25	0	8	382	Denka Co - QuickNavi COVID-19 Ag	Yes	Direct	NP alone	0.76 [0.58, 0.89]	1.00 [0.99, 1.00]
Osmanodja 2021	0	0	1	105	Draeger Safety AG - Draeger Ag SARS-CoV-2	Yes	Direct	Nasal (AN)	0.00 [0.00, 0.97]	1.00 [0.97, 1.00]
Salcedo 2021	29	1	6	75	E25Bio - Covid-19 DART	Unclear	Saline	Nasal (nos)	0.83 [0.66, 0.93]	0.99 [0.93, 1.00]
Nagura-Ikeda 2020	2	0	13	0	Fujirebio - ESPLINE SARS-CoV-2	No	Direct	Saliva	0.13 [0.02, 0.40]	Not estimable
Schuit 2021b(a)	8	1	23	452	Hangzhou AllTest Biotech - Covid-19 Ag	Yes	Direct	Saliva	0.26 [0.12, 0.45]	1.00 [0.99, 1.00]
Iftner 2022(b)	0	10	0	466	Hangzhou Clongene Biotech - COVID-19 Ag	Yes	Direct	Nasal (nos)	Not estimable	0.98 [0.96, 0.99]
Ferguson 2021	2	0	6	712	Innova Medical Group - SARS-CoV-2 Ag	No	Direct	NP alone	0.25 [0.03, 0.65]	1.00 [0.99, 1.00]
Garcia-Finana 2021	28	3	42	5431	Innova Medical Group - SARS-CoV-2 Ag	Yes	Direct	Nasal+OP	0.40 [0.28, 0.52]	1.00 [1.00, 1.00]
Homza 2021a(b)	6	0	7	74	Joysbio Biotech - SARS-CoV-2 Ag	Yes	Direct	NP alone	0.46 [0.19, 0.75]	1.00 [0.95, 1.00]
Thakur 2021	29	1	55	592	Lab Care Diagnostics - ACCUCARE Covid-19 Ag	Yes	Direct	NP alone	0.35 [0.24, 0.46]	1.00 [0.99, 1.00]
Baro 2021 [D]	46	20	55	165	Lepu Medical - SARS-CoV-2 Ag Rapid Test	No	VTM	NP alone	0.46 [0.36, 0.56]	0.89 [0.84, 0.93]
Burdino 2021	46	0	14	0	LumiraDx - SARS-CoV-2 Ag	Unclear	Not specified	Nasal (nos)	0.77 [0.64, 0.87]	Not estimable
Fernandez 2022	7	0	2	18	LumiraDx - SARS-CoV-2 Ag	Unclear	Direct	Nasal (nos)	0.78 [0.40, 0.97]	1.00 [0.81, 1.00]
Zobrist 2022 [C]	10	0	32	0	LumiraDx - SARS-CoV-2 Ag	Yes	Direct	Nasal (AN)	0.24 [0.12, 0.39]	Not estimable
Leli 2021	26	20	28	303	LumiraDx - SARS-CoV-2 Ag	Yes	Direct	Nasal (AN)	0.48 [0.34, 0.62]	0.94 [0.91, 0.96]
Kruger 2021	7	1	2	262	LumiraDx - SARS-CoV-2 Ag	Yes	Direct	Nasal (NMT)	0.78 [0.40, 0.97]	1.00 [0.98, 1.00]
Drain 2021	23	0	5	194	LumiraDx - SARS-CoV-2 Ag	Yes	Direct	Nasal (AN)	0.82 [0.63, 0.94]	1.00 [0.98, 1.00]
Bianco 2021	93	44	8	531	LumiraDx - SARS-CoV-2 Ag	Yes	Direct	Nasal (nos)	0.92 [0.85, 0.97]	0.92 [0.90, 0.94]
Iftner 2022(d)	0	1	0	462	MEXACARE - Coronavirus Ag	Yes	Direct	Nasal (nos)	Not estimable	1.00 [0.99, 1.00]
Kurihara 2021	30	2	17	491	Mizuho Medy - Quick Chaser Auto	Unclear	Direct	NP alone	0.64 [0.49, 0.77]	1.00 [0.99, 1.00]
Cubas-Atienzar 2021a	19	0	5	47	Mologic - COVID 19 Rapid Ag	Unclear	Direct	Mixed	0.79 [0.58, 0.93]	1.00 [0.92, 1.00]
Ifko 2021	9	7	0	139	Nal Von Minden - NADAL COVID-19 Ag	Yes	Direct	NP alone	1.00 [0.66, 1.00]	0.95 [0.90, 0.98]
Homza 2021a(c)	9	31	10	41	NDFOS - ND COVID-19 Ag test	Yes	Direct	NP alone	0.47 [0.24, 0.71]	0.57 [0.45, 0.69]
Chiu 2021	32	18	6	22938	PHASE scientific - INDICAID COVID-19 Ag	Yes	Direct	Nasal (AN)	0.84 [0.69, 0.94]	1.00 [1.00, 1.00]
Caruana 2021a [C]	8	0	16	215	Precision Biosensor - Exdia COVID-19 Ag	Yes	VTM	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
FIND 2021	102	2	28	854	Premier Medical Corp - Sure Status COVID-19 Ag	Yes	Direct	NP alone	0.78 [0.70, 0.85]	1.00 [0.99, 1.00]
Harris 2021	6	7	13	1525	Quidel - SOFIA SARS Antigen FIA	Yes	Direct	Nasal (AN)	0.32 [0.13, 0.57]	1.00 [0.99, 1.00]
Pray 2021	7	14	10	840	Quidel - SOFIA SARS Antigen FIA	Yes	Direct	Nasal (NMT)	0.41 [0.18, 0.67]	0.98 [0.97, 0.99]
Ford 2021a	10	16	11	836	Quidel - SOFIA SARS Antigen FIA	Yes	Direct	Nasal (NMT)	0.48 [0.26, 0.70]	0.98 [0.97, 0.99]
Brihn 2021	49	8	32	1643	Quidel - SOFIA SARS Antigen FIA	Yes	Direct	Nasal (AN)	0.60 [0.49, 0.71]	1.00 [0.99, 1.00]
Smith 2021b	33	4	9	1160	Quidel - SOFIA SARS Antigen FIA	Yes	Direct	NP alone	0.79 [0.63, 0.90]	1.00 [0.99, 1.00]
Schildgen 2021 [A]	4	1	9	13	RapiGEN - BIOCREDIT COVID-19 Ag	No	Not specified	TS or TW or TA	0.31 [0.09, 0.61]	0.93 [0.66, 1.00]
Shrestha 2020	40	0	7	66	RapiGEN - BIOCREDIT COVID-19 Ag	Unclear	Direct	NP alone	0.85 [0.72, 0.94]	1.00 [0.95, 1.00]
Kahn 2021	20	25	22	2273	SD Biosensor - STANDARD F COVID-19 Ag	Unclear	Not specified	NP or OP	0.48 [0.32, 0.64]	0.99 [0.98, 0.99]
Zellmer 2021	0	1	1	527	SD Biosensor - STANDARD F COVID-19 Ag	Yes	Direct	NP or OP	0.00 [0.00, 0.97]	1.00 [0.99, 1.00]
Menchinelli 2021a	18	48	25	1724	SD Biosensor - STANDARD F COVID-19 Ag	Yes	Direct	NP alone	0.42 [0.27, 0.58]	0.97 [0.96, 0.98]

Figure 12. (Continued)



Kahn 2021	20	25	22	2273	SD Biosensor - STANDARD F COVID-19 Ag	Unclear	Not specified	NP or OP	0.48 [0.32, 0.64]	0.99 [0.98, 0.99]
Zellmer 2021	0	1	1	527	SD Biosensor - STANDARD F COVID-19 Ag	Yes	Direct	NP or OP	0.00 [0.00, 0.97]	1.00 [0.99, 1.00]
Menchinelli 2021a	18	48	25	1724	SD Biosensor - STANDARD F COVID-19 Ag	Yes	Direct	NP alone	0.42 [0.27, 0.58]	0.97 [0.96, 0.98]
Drevinek 2020 [B]	24	0	31	0	SD Biosensor - STANDARD F COVID-19 Ag	Yes	Direct	NP alone	0.44 [0.30, 0.58]	Not estimable
Schuit 2021b(b)	7	2	24	454	SD Biosensor - STANDARD Q COVID-Ag (Nasal)	Yes	Direct	Nasal (AN)	0.23 [0.10, 0.41]	1.00 [0.98, 1.00]
Zobrist 2022 [A]	12	0	30	0	SD Biosensor - STANDARD Q COVID-Ag (Nasal)	Yes	Direct	Nasal (AN)	0.29 [0.16, 0.45]	Not estimable
Jakobsen 2021b	32	0	34	7008	SD Biosensor - STANDARD Q COVID-Ag (Nasal)	Yes	Direct	Nasal (AN)	0.48 [0.36, 0.61]	1.00 [1.00, 1.00]
Kriemler 2021	0	6	1	623	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	Direct	Buccal	0.00 [0.00, 0.97]	0.99 [0.98, 1.00]
Lopera 2022	6	0	44	89	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.12 [0.05, 0.24]	1.00 [0.96, 1.00]
Kumar 2021b	2	0	10	192	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	Direct or VTM	NP+OP	0.17 [0.02, 0.48]	1.00 [0.98, 1.00]
Zobrist 2022 [B]	7	0	35	0	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	Direct	Saliva	0.17 [0.07, 0.31]	Not estimable
Caruana 2021a [A]	8	0	16	215	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Cerutti 2020	2	0	3	140	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.40 [0.05, 0.85]	1.00 [0.97, 1.00]
Baro 2021 [C]	44	7	57	178	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.44 [0.34, 0.54]	0.96 [0.92, 0.98]
Jegerlehner 2021	11	1	14	325	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.44 [0.24, 0.65]	1.00 [0.98, 1.00]
Mungomklang 2021	35	3	38	1024	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	VTM	NP alone	0.48 [0.36, 0.60]	1.00 [0.99, 1.00]
Schildgen 2021 [C]	11	12	2	2	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	No	Not specified	TS or TW or TA	0.85 [0.55, 0.98]	0.14 [0.02, 0.43]
Von Ahnen 2021	12	0	1	906	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Unclear	Not specified	NP alone	0.92 [0.64, 1.00]	1.00 [1.00, 1.00]
Korenkov 2021	18	1	62	729	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP+OP	0.23 [0.14, 0.33]	1.00 [0.99, 1.00]
Caruana 2021b	2	2	5	107	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.29 [0.04, 0.71]	0.98 [0.94, 1.00]
Aleem 2022	6	1	14	328	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.30 [0.12, 0.54]	1.00 [0.98, 1.00]
Wertenauer 2021 [A]	37	2	79	1124	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP+OP	0.32 [0.24, 0.41]	1.00 [0.99, 1.00]
Pandey 2021	5	2	10	170	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.33 [0.12, 0.62]	0.99 [0.96, 1.00]
Boum 2021	33	0	56	0	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.37 [0.27, 0.48]	Not estimable
Reichert 2021	7	1	11	347	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.39 [0.17, 0.64]	1.00 [0.98, 1.00]
Jakobsen 2021a	29	11	30	2938	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.49 [0.36, 0.63]	1.00 [0.99, 1.00]
Homza 2021a(d)	4	0	4	64	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.50 [0.16, 0.84]	1.00 [0.94, 1.00]
Venekamp 2022(b)	34	1	29	594	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.54 [0.41, 0.67]	1.00 [0.99, 1.00]
Konstantinus 2021	4	0	3	55	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.57 [0.18, 0.90]	1.00 [0.94, 1.00]
Schuit 2021a(b)	60	6	41	1307	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.59 [0.49, 0.69]	1.00 [0.99, 1.00]
Holzner 2021	31	3	19	783	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.62 [0.47, 0.75]	1.00 [0.99, 1.00]
Venekamp 2022(c)	29	0	17	689	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	Nasal+OP	0.63 [0.48, 0.77]	1.00 [0.99, 1.00]
Turcato 2021	65	11	38	2594	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.63 [0.53, 0.72]	1.00 [0.99, 1.00]
Abdul-Mumin 2021	13	1	6	38	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.68 [0.43, 0.87]	0.97 [0.87, 1.00]
Gupta 2021	9	1	4	113	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.69 [0.39, 0.91]	0.99 [0.95, 1.00]
Pena 2021	51	3	22	766	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.70 [0.58, 0.80]	1.00 [0.99, 1.00]
Fernandez-Montero 2021	31	7	13	2465	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.70 [0.55, 0.83]	1.00 [0.99, 1.00]
Kawser 2021(b)	22	0	8	100	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.73 [0.54, 0.88]	1.00 [0.96, 1.00]
Le Goff 2021	24	8	8	782	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Yes	Direct	NP alone	0.75 [0.57, 0.89]	0.99 [0.98, 1.00]
Suzuki 2021	13	3	14	295	Sekisui Medical Co Ltd - RapidTesta SARS-CoV-2	Yes	Direct	NP alone	0.48 [0.29, 0.68]	0.99 [0.97, 1.00]
Parada-Ricart 2021	0	9	1	34	Shenzhen Bioeasy Biotech - 2019-nCoV Ag	Yes	Direct	Nasal (nos)	0.00 [0.00, 0.97]	0.79 [0.64, 0.90]
Baro 2021 [B]	52	3	49	182	Siemens - CLINITEST Rapid COVID-19 Ag	No	VTM	NP alone	0.51 [0.41, 0.62]	0.98 [0.95, 1.00]
Boyle 2021	0	0	2	88	Siemens - CLINITEST Rapid COVID-19 Ag	Yes	Direct	Nasal+OP	0.00 [0.00, 0.84]	1.00 [0.96, 1.00]
Torres 2021b	15	0	10	67	Siemens - CLINITEST Rapid COVID-19 Ag	Yes	Direct	NP alone	0.60 [0.39, 0.79]	1.00 [0.95, 1.00]
Merino-Amador 2021	23	0	2	15	Siemens - CLINITEST Rapid COVID-19 Ag	Yes	Direct	NP alone	0.92 [0.74, 0.99]	1.00 [0.78, 1.00]
Garcia-Cardenas 2021	46	5	15	382	Sorrento - COVISTIX Ag	Yes	Direct	Nasal (nos)	0.75 [0.63, 0.86]	0.99 [0.97, 1.00]
Baro 2021 [E]	29	4	72	181	SureScreen Diagnostics - SureScreen V	No	VTM	NP alone	0.29 [0.20, 0.39]	0.98 [0.95, 0.99]
Homza 2021a(e)	4	5	13	93	VivaChek Biotech - VivaDiag SARS-CoV-2 Ag	Yes	Direct	NP alone	0.24 [0.07, 0.50]	0.95 [0.88, 0.98]

Figure 13. Forest plot of studies reporting within-study comparisons by test brand Ag: antigen; AN: anterior nasal; NP: nasopharyngeal; OP: oropharyngeal; TA: throat aspirate; TS: throat swab; TW: throat wash; VTM: viral transport medium



Study	TP	FP	FN	TN	Test	Swab testing	Sample IFU compliant	Sample type	Sensitivity (95% CI)	Specificity (95% CI)
Baro 2021 [A]	39	1	62	184	Abbott - Panbio Covid-19 Ag	VTM	No	NP alone	0.39 [0.29, 0.49]	0.99 [0.97, 1.00]
Baro 2021 [B]	52	3	49	182	Siemens - CLINITEST Rapid COVID-19 Ag	VTM	No	NP alone	0.51 [0.41, 0.62]	0.98 [0.95, 1.00]
Baro 2021 [C]	44	7	57	178	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	VTM	No	NP alone	0.44 [0.34, 0.54]	0.96 [0.92, 0.98]
Baro 2021 [D]	46	20	55	165	Lepu Medical - SARS-CoV-2 Ag Rapid Test	VTM	No	NP alone	0.46 [0.36, 0.56]	0.89 [0.84, 0.93]
Baro 2021 [E]	29	4	72	181	SureScreen Diagnostics - SureScreen V	VTM	No	NP alone	0.29 [0.20, 0.39]	0.98 [0.95, 0.99]
Caruana 2021a [A]	8	0	16	215	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	VTM	No	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [B]	8	1	16	214	Abbott - Panbio Covid-19 Ag	VTM	No	NP alone	0.33 [0.16, 0.55]	1.00 [0.97, 1.00]
Caruana 2021a [C]	8	0	16	215	Precision Biosensor - Exdia COVID-19 Ag	VTM	Yes	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Caruana 2021a [D]	8	0	16	215	Becton Dickinson - BD Veritor	VTM	No	NP alone	0.33 [0.16, 0.55]	1.00 [0.98, 1.00]
Drevinek 2020 [A]	24	0	31	0	Abbott - Panbio Covid-19 Ag	Direct	Yes	NP alone	0.44 [0.30, 0.58]	Not estimable
Drevinek 2020 [B]	24	0	31	0	SD Biosensor - STANDARD F COVID-19 Ag	Direct	Yes	NP alone	0.44 [0.30, 0.58]	Not estimable
Schildgen 2021 [A]	4	1	9	13	RapiGEN - BIOCREDIT COVID-19 Ag	Not specified	No	TS or TW or TA	0.31 [0.09, 0.61]	0.93 [0.66, 1.00]
Schildgen 2021 [B]	5	4	8	10	Abbott - Panbio Covid-19 Ag	Not specified	No	TS or TW or TA	0.38 [0.14, 0.68]	0.71 [0.42, 0.92]
Schildgen 2021 [C]	11	12	2	2	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Not specified	No	TS or TW or TA	0.85 [0.55, 0.98]	0.14 [0.02, 0.43]
Wertenauer 2021 [A]	37	2	79	1124	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Direct	Yes	NP+OP	0.32 [0.24, 0.41]	1.00 [0.99, 1.00]
Wertenauer 2021 [B]	27	0	89	1126	Abbott - Panbio Covid-19 Ag	Direct	Yes	NP+OP	0.23 [0.16, 0.32]	1.00 [1.00, 1.00]
Zobrist 2022 [A]	12	0	30	0	SD Biosensor - STANDARD Q COVID-Ag (Nasal)	Direct	Yes	Nasal (AN)	0.29 [0.16, 0.45]	Not estimable
Zobrist 2022 [B]	7	0	35	0	SD Biosensor/Roche - STANDARD Q COVID-19 Ag	Direct	No	Saliva	0.17 [0.07, 0.31]	Not estimable
Zobrist 2022 [C]	10	0	32	0	LumiraDx - SARS-CoV-2 Ag	Direct	Yes	Nasal (AN)	0.24 [0.12, 0.39]	Not estimable

Accuracy of antigen tests overall and by subgroup

Results showed high levels of heterogeneity in sensitivity with consistently high specificity (Figure 4). Average sensitivity was 55.0% (95% CI 50.9%, 59.0%) and average specificity was 99.5% (95% CI 99.5%, 99.6%) across the 147 evaluations of Ag-RDTs reporting both sensitivity and specificity (based on 149,251 samples, including 7636 samples with confirmed SARS-CoV-2; Table 2). Adding the 11 test evaluations from 'sensitivity only' studies and six 'specificity only' datasets had a negligible impact on results (Table 2). Sensitivity analyses excluding data from the five 'mainly asymptomatic' cohorts had a similarly negligible effect (Supplementary material 14).

Secondary analyses by eligibility for testing and/or reported exposure to SARS-CoV-2

Secondary analyses by reported exposure to SARS-CoV-2 (where possible using subgroup data by reported exposure for studies recruiting asymptomatic individuals with and without reported contact with a confirmed case of SARS-CoV-2) suggested that sensitivity may be higher when an epidemiological exposure to SARS-CoV-2 is suspected (based on studies reporting specific criteria for testing or referral for testing of those without symptoms) compared to where COVID-19 testing was reported to be widely available to asymptomatic participants regardless of epidemiological exposure (Table 2; Figure 5). The absolute difference in sensitivity was 5.7 percentage points higher (95% CI from -2.8 to 14.1 percentage points) when epidemiological exposure to SARS-CoV-2 was suspected (sensitivity 58.6%, 95%

CI 51.4% to 65.5% compared to 53.0%, 95% CI 48.4% to 57.5%; based on 43 evaluations in 15,516 samples with 1483 cases and 103 evaluations with 129,032 samples and 5660 cases, respectively). Summary sensitivity in the 23 studies providing data for 'mainly asymptomatic' populations was 61.5% (95% CI 52.8% to 69.5%), based on data from 2740 cases.

Average specificity was similarly high (99.4% or 99.6%) with or without likely epidemiological exposure, a difference that is statistically (but not likely to be clinically) significant (-0.2 percentage points difference, 95% CI from −0.4 to -0.08; Table 2). Summary specificity for the 'mainly asymptomatic' populations was 99.5% (95% CI 99.5% to 99.6%; 39,390 samples).

Adding data from sensitivity-only cohorts slightly decreased the difference in sensitivity between widely available testing and testing based on epidemiological exposure from 5.7 percentage points to 4.0 percentage points (95% CI from -1.7 to 9.6 percentage points; Supplementary material 14). Adding data from specificity-only cohorts had minimal effects on summary specificity.

Sensitivity analyses of the six within-study comparisons of accuracy in participants with and without reported contact with confirmed cases, suggested a larger difference in sensitivity of 7.6 percentage points (95% CI from -36.4 to 21.2 percentage points (Table 2; Figure 6)), with summary sensitivity 66.1% where contact was reported (95% CI 44.9% to 82.4%; 123 cases) compared to 58.5% (95% CI 37.1% to 77.1%; 159 cases) where no exposure was reported.

Heterogeneity investigations

By study setting

Analyses for asymptomatic participants by study setting were frequently limited by the number of studies per group and relatively low numbers of confirmed SARS-CoV-2 cases for some subgroups. Average sensitivities were similar for asymptomatic participants presenting to COVID-19 test centres (56.7%, 95% CI 52.1% to 61.2%; based on 69 evaluations including 66,021 samples and 4482 cases) or emergency care settings (average sensitivity 54.7%, 95% CI 34.1% to 73.8%; based on 10 evaluations with 8184 samples and 411 cases; Table 2; Figure 4). For studies conducted in hospital settings, summary sensitivities ranged from 34.1% (95% CI 24.9% to 44.8%) for testing hospital outpatients (2 evaluations, 1206 participants and 85 SARS-CoV-2 cases) to 61.8% (95% CI 31.8% to 84.9%) for studies reporting testing of any hospital patient, visitor or staff (5 evaluations; 6019 participants, 358 SARS-CoV-2 cases). Summary sensitivity for testing hospital inpatients was 39.8% (95% CI 27.3% to 53.8%) (12 evaluations; 6245 participants, 291 cases); these evaluations included pre-procedural testing of patients (e.g. Rottenstreich 2021; Stokes 2021) as well as admissions to hospital wards, intermediate care units or ICU from the emergency department (Caruana 2021a [A]; Caruana 2021a [B]; Caruana 2021a [C]; Caruana 2021a [D]).

A total of 25 evaluations reporting both sensitivity and specificity were considered to represent screening scenarios (Table 2; Figure 4), with average sensitivities of 40.2% (95% CI 3.6% to 92.3%) for asymptomatic healthcare worker screening (4 evaluations; 3441 participants, 145 cases), 40.6% (95% CI 29.7% to 52.6%) for screening school or university students or staff (10 evaluations; 18,721 participants, 261 cases), and 42.1% (95% CI 36.9% to 47.5%) for community screening scenarios (7 evaluations; 8034 participants, 648 cases). Summary sensitivity for other targeted screening programmes was 74.3% (95% CI 50.3% to 89.2%) (3 evaluations; 23,922 participants and 76 cases), with sensitivities in individual studies ranging from 55.6% (Di Domenico 2021) to 100% (Revollo 2021 [B]) for screening apparently healthy people attending outdoor events (36 and two RT-PCR positive cases, respectively) and 84.2% (Chiu 2021) for screening individuals at emergency outbreak centres (38 RT-PCR positive cases). The number of evaluations from other study settings ranged from one to five, with between 47 and 131 cases (summary sensitivities from 47.8% to 76.4%; Table 2).

Average specificities by study setting were at least 98.8% for the majority of subgroups; outliers included average specificity of 77.8% (95% CI 44.0%, 94.0%) for three studies with unclear study settings (284 participants) and 95.9% (91.6%, 98.0%) for three studies conducted in nursing homes (225 participants) (Table 2).

The inclusion of data from sensitivity-only or specificity-only cohorts made only marginal differences to summary sensitivity or specificity estimates (Supplementary material 14).

By time after reported contact with confirmed case

Insufficient data were available to allow a meaningful comparison of the effect of time after contact with a confirmed case of SARS-COV-2 (week 1 compared to week 2 or later; Table 2; Supplementary material 15 - Figure 7). Two evaluations reported both sensitivity and specificity for the first week after contact (Bulilete 2021; Siddiqui 2021); average sensitivity was 81.6% (95% CI 51.8% to 94.8%), and specificity 99.7% (95% CI 99.0% to 99.9%; 950 samples and 51 cases). Two evaluations reported sensitivity and specificity for week two or later after contact (Bulilete 2021; Ford 2021b); average sensitivity was 65.5% (95% CI 46.9% to 80.3%) and specificity 99.8% (95% CI 98.2% to 99.96%) (429 samples and 29 cases; Table 2).

By Ct value

A total of 29 evaluations in asymptomatic populations reported sensitivity according to sample viral load using RT-PCR Ct values as a proxy. Insufficient data for meta-analysis were available according to RNA copies/mL.

Because of the continuous nature of viral load measurement, and the lack of evidence for a step-change in RDT sensitivity above or below any single threshold value, we report results for assay sensitivity in three subgroups (Table 2; Supplementary material 15 - Figure 8). For participant samples with the lowest Ct values (less than 25 Ct) suggesting higher viral loads, summary sensitivities were 91.3% (95% CI 83.1%, 95.7%; 18 evaluations with 710 RT-PCR positive samples). For samples in the 25 to 30 Ct range, summary sensitivity was 50.9% (95% CI 25.8% to 75.5%; 13 evaluations with 248 cases). Average sensitivity from evaluations reporting results for samples with Ct values greater than 30 Ct was 14.6% (95% CI 9.7% to 21.4%) based on 762 cases from 25 evaluations (Table 2). The pattern of results mirrors results from our previous review iteration, which included samples regardless of symptom status [4].

By age (children vs adults)

Five evaluations allowed a within-study comparison of sensitivity and specificity in children versus adults (so minimising the effect from other differences) (Table 2; Supplementary material 15 - Figure 9). Average sensitivity was 5.7 percentage points higher in

adults (95% CI -6.0 to 17.5 percentage points) with no difference in average specificity (both 99.7%). The number of SARS-CoV-2 cases in children was relatively small (250 compared to 801 adults) and the observed difference in sensitivity is within that which might be observed by chance (Table 2).

By sample type

The majority of evaluations (n = 80 for studies reporting both sensitivity and specificity) obtained nasopharyngeal samples from all study participants, either as the sole sample type, or in combination with oropharyngeal sampling in some or all participants. Average sensitivity was 52.8% (95% CI 47.7% to 58.0%) and average specificity was 99.4% (95% CI 99.3% to 99.5%) in 46,336 samples, including 3340 cases of SARS-CoV-2; Table 2; Supplementary material 15 - Figure 10. Average sensitivity in 44 studies using nasal samples (anterior nasal in 30, nasal mid-turbinate in 7, and nasal not further specified in 7) was 59.8% (53.0% to 66.2%) and average specificity was 99.6% (99.6% to 99.6%) in 84,207 samples including 3332 cases; an increase in sensitivity of 6.9 percentage points compared to studies in the nasopharyngeal sample group (95% CI -1.5 to 15.4 percentage points higher). Evaluations using a combination of nasal and oropharyngeal samples were less sensitive on average compared to those using nasopharyngeal samples (summary sensitivity 47.2%, 95% CI 29.3% to 65.9%; 6 evaluations and 367 cases); however, the difference observed was within that expected by chance (-5.6 percentage points lower, 95% CI from -25.5 to 14.2 percentage points).

Results were very similar when 'sensitivity only' and specificity only' evaluations were added (Supplementary material 14).

The observed differences in sensitivity according to sample type may be confounded by a number of factors, including the populations studied, timing of tests in regard to course of infection and variations in accuracy of the tests used. Some caution is therefore needed when considering results based on subgroup analysis of all data contributing to the primary analysis. Only six studies reported within-study comparisons by sample type (that is, using the same Ag-RDT brand on different samples obtained from the same patient) such that meaningful comparisons of accuracy were not possible (data presented in Table 2; Supplementary material 15 - Figure 11).

Subgroup analyses, including data from 'sensitivity-alone' evaluations, produced similar average sensitivities and differences in sensitivity between sample types (Supplementary material 14).

Average specificities were greater than 99% for all the main sample types apart from in the 12 evaluations of either naso- or oropharyngeal samples where average specificity was 98.4% (95% CI 98.0% to 98.7%; Table 2).

By assay format

We found limited evidence for differences in accuracy according to assay format (Table 2). Average sensitivity was higher for evaluations using a CGIA at 53.4% (95% CI 48.7% to 58.1%; 107 evaluations; 123,687 samples, 5734 cases) compared to FIA (average sensitivity 46.2% (95% CI 31.0% to 62.2%); 10 evaluations; 11,200 samples, 291 cases); however, results from individual studies were highly heterogeneous, and the difference was not statistically significant. Average specificities were 99.7% (95% CI 99.7% to 99.7%) for CGIAs and 98.8% (95% CI 98.6% to 99.0%) for FIAs; a difference of −0.9 percentage points (95% CI −1.1 to −0.7 percentage points). Results for LFAs where the method could not be determined (n = 16) were in a similar range (average 53.1%) (Table 2). Average sensitivities for latex-conjugated LFAs (4 evaluations in 2773 samples, 320 cases) and microfluidic fluorescent immunoassays (5 evaluations in 1574 samples, 201 cases) were higher, 66.6% (95% CI 61.2% to 71.5%) and 78.8% (95% CI 60.1% to 90.1%), respectively. No statistical comparison was made due to the small numbers of evaluations and participants.

By test brand

Results by test brand for asymptomatic participants are presented in Supplementary material 16, including sensitivity analyses by IFU compliance (based on sample type, use of VTM, and time period between sample collection and test procedure).

We observed considerable heterogeneity in sensitivities across the different assays and evaluations (Supplementary material 17 – Figure 12), at least in part due to the frequently small number of RT-PCR positive cases included. Of the 41 test brands evaluated in asymptomatic or mainly asymptomatic participants, 25 brands had one evaluation (mean of 32 cases per evaluation) and 16 brands had two or more evaluations each (mean of 85 cases per evaluation).

None of the assays met the WHO acceptable performance standard for sensitivity (of 80%) based on meta-analysis, i.e. for the brands for which meta-analysis was possible, all the summary sensitivity estimates were below 80% (Supplementary material 16). Sensitivities from individual studies where meta-analysis was not possible, exceeded 80% for three different assays (i.e. the assays from E25Bio (Salcedo 2021), Nal von Minden (Ifko 2021), and PHASE scientific (Chiu 2021)); however, 95% confidence intervals were wide due to low numbers of cases (ranging from 66.4% up to 100%). The plot of individual study results (Supplementary material 17 - Figure 12) shows that a number of additional studies demonstrated sensitivities of 80% or more, but only one was based on a sample of at least 100 cases (sensitivity 92.0%, 95% CI 85.0% to 97.0% for the LumiraDx assay (Bianco 2021)), suggesting that under some circumstances, assays can perform well in terms of sensitivity; however, considerable uncertainty remains. Specificities were consistently high across different brands of test (Supplementary material 17).

A detailed summary of meta-analysis results by test brand and IFU compliance is provided in Supplementary material 18.

Additional secondary analyses including data from symptomatic participants

Of the 131 included primary study reports, 11 reported data for prespecified subgroups of interest in populations including both symptomatic and asymptomatic participants (total of 18 cohorts or 'studies'). Results are briefly presented below and are reported in Supplementary material 19 and displayed in forest plots in Supplementary material 20.

By age

Four studies reported within-study comparisons of accuracy in children compared to adults (Supplementary material 20 – Figure 14). Summary sensitivities were higher compared to those reported for asymptomatic populations alone (70.1% for

children (95% CI 53.9% to 82.5%; 677 samples, 124 cases) and 76.2% for adults (95% CI 63.9% to 85.3%; 6370 samples, 938 cases)); however, the difference in sensitivity between children and adults was very similar (6.1 percentage points higher in adults compared to in children, 95% CI -12.1 to 24.2 percentage points). Average specificity was 99.8% in children and 99.9% in adults (Supplementary material 19).

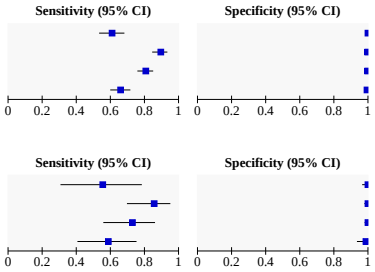
Figure 14. Forest plot of within-study comparisons by age in studies that included symptomatic participants AN: anterior nasal; NP: nasopharyngeal; y: year

Adult (within-study comparison)

Study	TP	FP	FN	TN	Sample type	Symptom status	Age	Sensitivity (95% CI)	Specificity (95% CI)
Masia 2021	108	0	69	602	NP alone	Mixed	Adult	0.61 [0.53, 0.68]	1.00 [0.99, 1.00]
Pilarowski 2020a	181	3	21	2888	Nasal (AN)	Mixed	Adult	0.90 [0.85, 0.93]	1.00 [1.00, 1.00]
Ford 2021b	240	2	57	1586	Nasal (AN)	Mixed	Adult	0.81 [0.76, 0.85]	1.00 [1.00, 1.00]
Schrom 2022	173	2	89	349	Nasal (AN)	Mixed	Adult	0.66 [0.60, 0.72]	0.99 [0.98, 1.00]

Children (includes symptomatic)

Study	TP	FP	FN	TN	Sample type	Symptom status	Age	Sensitivity (95% CI)	Specificity (95% CI)
Masia 2021	10	0	8	107	NP alone	Mixed	Paediatric <=14 y	0.56 [0.31, 0.78]	1.00 [0.97, 1.00]
Pilarowski 2020a	30	0	5	174	Nasal (AN)	Mixed	Paediatric <18 y	0.86 [0.70, 0.95]	1.00 [0.98, 1.00]
Ford 2021b	27	0	10	188	Nasal (AN)	Mixed	Paediatric <18 y	0.73 [0.56, 0.86]	1.00 [0.98, 1.00]
Schrom 2022	20	1	14	83	Nasal (AN)	Mixed	Paediatric <=12 y	0.59 [0.41, 0.75]	0.99 [0.94, 1.00]



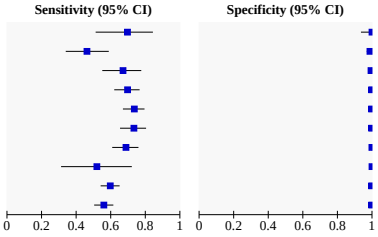
By vaccination status

Nine studies reported 10 within-study comparisons of accuracy according to prior vaccination (Supplementary material 20 – Figure 15). No difference in average sensitivity (2.0 percentage points (95% CI from -7.5 to 11.5 percentage points, based on 442 vaccinated and 1508 unvaccinated cases of SARS-CoV-2)) and a marginal difference in average specificity (-0.4 percentage points, 95% CI from -0.6 to -0.2 percentage points, based on 5940 vaccinated and 10,233 not vaccinated individuals) was observed (Supplementary material 19).

Figure 15. Forest plot of data by vaccination status and prior SARS-CoV-2 infection in studies that included symptomatic participants

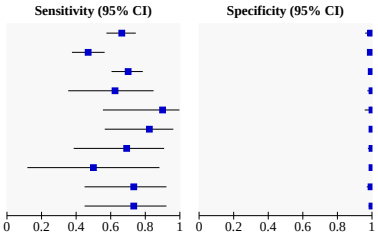
Not vaccinated

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Schrom 2022	23	0	10	56	Mixed	COVID-19 test centre	0.70 [0.51, 0.84]	1.00 [0.94, 1.00]
Schuit 2021b(a)	31	4	36	333	Mainly symptomatic	COVID-19 test centre	0.46 [0.34, 0.59]	0.99 [0.97, 1.00]
Schuit 2021b(b)	49	2	24	346	Mainly symptomatic	COVID-19 test centre	0.67 [0.55, 0.78]	0.99 [0.98, 1.00]
Venekamp 2022(a)	113	2	49	1091	Asymptomatic - any	COVID-19 test centre	0.70 [0.62, 0.77]	1.00 [0.99, 1.00]
Venekamp 2022(b)	151	3	54	1451	Mixed	COVID-19 test centre	0.74 [0.67, 0.80]	1.00 [0.99, 1.00]
Venekamp 2022(c)	105	2	38	1267	Mixed	COVID-19 test centre	0.73 [0.65, 0.80]	1.00 [0.99, 1.00]
Venekamp 2022(d)	106	1	48	1662	Mixed	COVID-19 test centre	0.69 [0.61, 0.76]	1.00 [1.00, 1.00]
Venekamp 2022(e)	13	0	12	627	Mixed	COVID-19 test centre	0.52 [0.31, 0.72]	1.00 [0.99, 1.00]
Wertenauer 2021 [A]	193	3	130	1690	Mixed	COVID-19 test centre	0.60 [0.54, 0.65]	1.00 [0.99, 1.00]
Wertenauer 2021 [B]	181	2	142	1691	Mixed	COVID-19 test centre	0.56 [0.50, 0.62]	1.00 [1.00, 1.00]



Vaccinated (primary series only)

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Schrom 2022	85	1	43	138	Mixed	COVID-19 test centre	0.66 [0.58, 0.75]	0.99 [0.96, 1.00]
Schuit 2021b(a)	54	22	61	2253	Mainly symptomatic	COVID-19 test centre	0.47 [0.38, 0.56]	0.99 [0.99, 0.99]
Schuit 2021b(b)	75	10	32	2272	Mainly symptomatic	COVID-19 test centre	0.70 [0.60, 0.79]	1.00 [0.99, 1.00]
Venekamp 2022(a)	10	0	6	136	Mixed	COVID-19 test centre	0.63 [0.35, 0.85]	1.00 [0.97, 1.00]
Venekamp 2022(b)	9	0	1	86	Mixed	COVID-19 test centre	0.90 [0.55, 1.00]	1.00 [0.96, 1.00]
Venekamp 2022(c)	14	0	3	207	Mixed	COVID-19 test centre	0.82 [0.57, 0.96]	1.00 [0.98, 1.00]
Venekamp 2022(d)	9	0	4	154	Mixed	COVID-19 test centre	0.69 [0.39, 0.91]	1.00 [0.98, 1.00]
Venekamp 2022(e)	3	0	3	295	Mixed	COVID-19 test centre	0.50 [0.12, 0.88]	1.00 [0.99, 1.00]
Wertenauer 2021 [A]	11	1	4	182	Mixed	COVID-19 test centre	0.73 [0.45, 0.92]	0.99 [0.97, 1.00]
Wertenauer 2021 [B]	11	0	4	183	Mixed	COVID-19 test centre	0.73 [0.45, 0.92]	1.00 [0.98, 1.00]

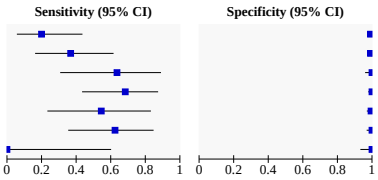


Vaccinated (primary series or not reported)

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Schrom 2022	25	0	24	117	Mixed	COVID-19 test centre	0.51 [0.36, 0.66]	1.00 [0.97, 1.00]

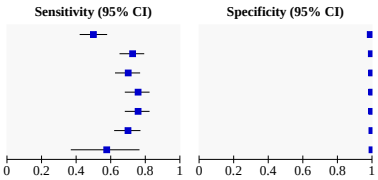
Prior SARS-CoV-2 infection

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Schuit 2021b(a)	4	3	16	343	Mainly symptomatic	COVID-19 test centre	0.20 [0.06, 0.44]	0.99 [0.97, 1.00]
Schuit 2021b(b)	7	3	12	350	Mainly symptomatic	COVID-19 test centre	0.37 [0.16, 0.62]	0.99 [0.98, 1.00]
Venekamp 2022(a)	7	0	4	91	Mixed	COVID-19 test centre	0.64 [0.31, 0.89]	1.00 [0.96, 1.00]
Venekamp 2022(b)	13	0	6	168	Mixed	COVID-19 test centre	0.68 [0.43, 0.87]	1.00 [0.98, 1.00]
Venekamp 2022(c)	6	1	5	184	Mixed	COVID-19 test centre	0.55 [0.23, 0.83]	0.99 [0.97, 1.00]
Venekamp 2022(d)	10	0	6	118	Mixed	COVID-19 test centre	0.63 [0.35, 0.85]	1.00 [0.97, 1.00]
Venekamp 2022(e)	0	0	4	53	Mixed	COVID-19 test centre	0.00 [0.00, 0.60]	1.00 [0.93, 1.00]



No prior SARS-CoV-2 infection

Study	TP	FP	FN	TN	Symptom status	Setting	Sensitivity (95% CI)	Specificity (95% CI)
Schuit 2021b(a)	81	23	81	2242	Mainly symptomatic	COVID-19 test centre	0.50 [0.42, 0.58]	0.99 [0.98, 0.99]
Schuit 2021b(b)	117	9	44	2267	Mainly symptomatic	COVID-19 test centre	0.73 [0.65, 0.79]	1.00 [0.99, 1.00]
Venekamp 2022(a)	115	2	49	1091	Mixed	COVID-19 test centre	0.70 [0.62, 0.77]	1.00 [0.99, 1.00]
Venekamp 2022(b)	113	1	36	1287	Mixed	COVID-19 test centre	0.76 [0.68, 0.82]	1.00 [1.00, 1.00]
Venekamp 2022(c)	113	1	36	1287	Mixed	COVID-19 test centre	0.76 [0.68, 0.82]	1.00 [1.00, 1.00]
Venekamp 2022(d)	105	1	45	1699	Mixed	COVID-19 test centre	0.70 [0.62, 0.77]	1.00 [1.00, 1.00]
Venekamp 2022(e)	15	0	11	867	Mixed	COVID-19 test centre	0.58 [0.37, 0.77]	1.00 [1.00, 1.00]



By prior SARS-CoV-2 infection

Seven studies reported within-study comparisons of accuracy according to prior SARS-CoV-2 infection (Supplementary material 20 – Figure 15). Average sensitivity was considerably higher in those with no reported previous infection (68.5%, 95% CI 60.7% to 75.5%; 961 cases) compared to 46.7% (95% CI 34.3% to 59.6%; 100 cases) in those previously infected (Supplementary material 19). The difference in sensitivity was beyond that expected by chance (21.8 percentage points, 95% CI 6.9 to 36.7 percentage points higher). No meaningful difference in average specificity was observed (difference of 0.2 percentage points, 95% CI from -0.2 to 0.6 percentage points, based on 10,777 and 1314 participants with no prior infection reported).

By SARS-CoV-2 variant

Three studies reported four within-study comparisons of sensitivity for detection of the alpha SARS-CoV-2 variant (402 samples) compared to samples with other variants or wild-type SARS-CoV-2 (216 samples). Average sensitivity was 9.3 percentage points lower in samples with the alpha variant (95% CI from 3.0 to 15.6 percentage points) (Supplementary material 20 – Figure 16).

Figure 16. Forest plot of data by SARS-CoV-2 variant in studies that included symptomatic participants nos: not otherwise specified; PCR: polymerase chain reaction; WGS: whole genome sequencing

Alpha (B.1.1.7)

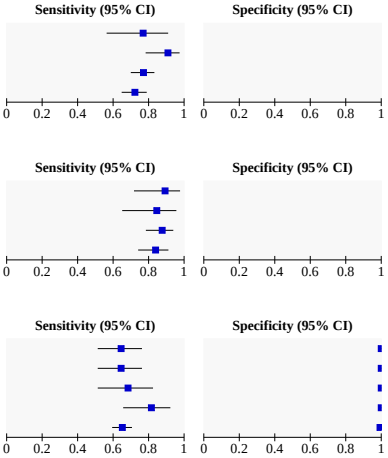
Study	TP	FP	FN	TN	Symptom status	Variant id.	Sensitivity (95% CI)	Specificity (95% CI)
Cubas-Atienzar 2021a	20	0	6	0	Mainly symptomatic	S-gene dropout	0.77 [0.56, 0.91]	Not estimable
Osmanodja 2021	40	0	4	0	Symptomatic	Typing (nos)	0.91 [0.78, 0.97]	Not estimable
Wertenauer 2021 [A]	128	0	38	0	Mixed	PCR (variant kit)	0.77 [0.70, 0.83]	Not estimable
Wertenauer 2021 [B]	120	0	46	0	Mixed	PCR (variant kit)	0.72 [0.65, 0.79]	Not estimable

Not Alpha (negative for investigated mutations)

Study	TP	FP	FN	TN	Symptom status	Variant id.	Sensitivity (95% CI)	Specificity (95% CI)
Cubas-Atienzar 2021a	25	0	3	0	Mainly symptomatic	S-gene dropout	0.89 [0.72, 0.98]	Not estimable
Osmanodja 2021	22	0	4	0	Symptomatic	Typing (nos)	0.85 [0.65, 0.96]	Not estimable
Wertenauer 2021 [A]	71	0	10	0	Mixed	PCR (variant kit)	0.88 [0.78, 0.94]	Not estimable
Wertenauer 2021 [B]	68	0	13	0	Mixed	PCR (variant kit)	0.84 [0.74, 0.91]	Not estimable

Omicron (B.1.1.529)

Study	TP	FP	FN	TN	Symptom status	Variant id.	Sensitivity (95% CI)	Specificity (95% CI)
Goodall 2022(a) [A]	40	0	22	763	Asymptomatic - any	S-gene dropout	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Goodall 2022(a) [B]	40	0	22	763	Asymptomatic - any	S-gene dropout	0.65 [0.51, 0.76]	1.00 [1.00, 1.00]
Goodall 2022(b) [A]	26	0	12	482	Asymptomatic - any	S-gene dropout	0.68 [0.51, 0.82]	1.00 [0.99, 1.00]
Goodall 2022(b) [B]	31	0	7	482	Asymptomatic - any	S-gene dropout	0.82 [0.66, 0.92]	1.00 [0.99, 1.00]
Schrom 2022	193	3	103	432	Mixed	WGS	0.65 [0.59, 0.71]	0.99 [0.98, 1.00]



Three studies reported five evaluations of accuracy for detection of the Omicron variant of SARS-CoV-2. Summary sensitivity was 66.5% (95% CI 62.3% to 70.5%) and specificity 99.9% (95% CI 99.7% to 100%; 2925 samples) (Supplementary material 19 – Figure 16).

DISCUSSION

This is the fourth iteration of a Cochrane living review summarising the accuracy of point-of-care antigen tests for detecting current SARS-CoV-2 infection. This version of the review is based on published journal articles or studies available as preprints from 9 March 2021 to 17 February 2022. In addition, we also included evaluations that were available as independent national reference laboratory publications or that were co-ordinated and published by FIND, and journal articles that were listed on the Diagnostics Global Health website to 3 February 2022.

Summary of main results

We included data from 146 studies evaluating the accuracy of Ag-RDTs in asymptomatic participants, including 144,250 participants (7104 samples with confirmed SARS-CoV-2). Key findings are presented in Summary of findings 1.

Key findings

We summarise eight key findings from this review.

1. Some methodological standards have improved

Some improvements in methodological standards can be observed for Ag-RDT evaluations compared to those in the previous version of this review, particularly with regard to the risk of bias for the reference standard and the applicability of evidence across all domains. These improvements are, to some extent, artefactual, due to the targeted nature of the review, which focuses on evidence for testing asymptomatic participants for whom there is no viable alternative reference standard for presence of infection, such as clinical confirmation. Requiring more than one molecular test result to confirm absence of infection would also be an unreasonable requirement for asymptomatic participants. Some concerns about risk of bias and particularly regarding applicability of results remain, including poor reporting about blinding of index and reference standard interpretation, missing data, lack of clarity about participant inclusion and exclusion from analyses, and use of assays intended for use in symptomatic populations. The latter has contributed to the increased percentage of studies showing high or unclear applicability regarding index test delivery that did not align with real-world use (increased from 31% in the previous review iteration to 93% in this one).

2. Sensitivity in asymptomatic participants is low

Sensitivity in asymptomatic participants is much lower than has been observed in those with signs and symptoms of COVID-19 [4]. Overall sensitivity was on average 55.0% (95% CI 50.9% to 59.0%). Sensitivity is higher when an epidemiological exposure to SARS-CoV-2 is suspected (studies reporting specific criteria for testing or referral for testing) compared to where COVID-19 testing was reported to be widely available to any asymptomatic participant on presentation for testing (an increase of 5.7 percentage points, 95% CI from -2.8 to 14.1 percentage points overall and 7.6 percentage points, 95% CI from -36.4 to 21.2 percentage points for analysis restricted to within-study comparison by reported contact with a confirmed case). Average sensitivities also appeared lower where individuals were tested as part of community or targeted screening programmes such as in schools (average sensitivity 40.6%, 95% CI 29.7% to 52.6%) or community screening programmes (42.1%, 95% CI 36.9% to 47.5%). These results are broadly similar to those reported in the previous review iteration, with a considerably greater number of studies and cases of SARS-CoV-2. Confidence intervals overlap, however, limiting the strength of conclusions that can be drawn from available data.

3. Steady decline in sensitivity with lower viral load

In this version of the review, sufficient data were available for an investigation of Ag-RDT accuracy by viral load in asymptomatic participants. We were only able to consider three categories of participants according to Ct value; however, the same pattern was observed as for the previous review iteration which included symptomatic participants. A steady decline in Ag-RDT summary sensitivities was observed, from 91.3% (95% CI 83.1%, 95.7%) in

participant samples with the highest viral load (< 25 Ct) to 50.9% (95% CI 25.8% to 75.5%) for samples in the 25 to 30 Ct range and 14.6% (95% CI 9.7% to 21.4%) for those with > 30 Ct. It is likely that, in the absence of symptoms prompting the use of an Ag-RDT, the observed lower sensitivity in an asymptomatic population is at least in part due to the tests being used when individuals have a relatively low viral load. We have previously shown that, for symptomatic populations, timing of the test in relation to the course of infection and according to Ct value, has a strong effect on observed sensitivity [4].

4. Compliance with manufacturers' instructions has improved

There has been a further improvement in the reporting of test procedures at the point of care, and the majority (71%) of evaluations followed the manufacturer IFUs in regard to sample type, and timing of tests. More than 80% of evaluations used direct swab testing (137/164, 84%), as is usually recommended on manufacturer IFUs, rather than storing samples in VTM or saline.

5. Very few assays have been shown to meet minimum acceptable sensitivity requirements in asymptomatic participants

There was considerable variation in sensitivities in asymptomatic participants between test brands; however, accuracy estimates from both meta-analysis and on an individual study level are likely to be affected by the variable case mix across studies, especially if any requirements for prior contact with a confirmed case were applied.

None of the assays met the WHO acceptable performance standard for sensitivity (of 80%) based on meta-analysis; however, the 95% CIs for summary sensitivities included 80% for three assays evaluated in at least 100 cases of confirmed SARS-CoV-2 infection (Becton Dickinson - BD Veritor, LumiraDx - SARS-CoV-2 Ag and Premier Medical Corp - Sure Status COVID-19 Ag). At an individual study level (where meta-analysis was not possible), sensitivities exceeded 80% for three assays; however, 95% of CIs were relatively wide, ranging from 66.4% to 100% (assays from E25Bio – Covid19 DART (Salcedo 2021), Nal von Minden (Ifko 2021) and PHASE Scientific (Chiu 2021)). Across all included studies, only one demonstrated sensitivity of 80% or more based on a sample of at least 100 cases (sensitivity 92.0%, 95% CI 85.0% to 97.0% for the LumiraDx assay (Bianco 2021) (Figure 12)). Although these results suggest that under some circumstances assays can perform well in terms of sensitivity, considerable uncertainty remains.

6. Lack of evidence for commercially produced tests

Despite a considerable increase in the number of studies evaluating point-of-care antigen tests in asymptomatic people, there remains a considerable lack of data for a significant proportion of commercially produced point-of-care tests. This review located evaluations for 49 brands of Ag-RDT; these represent a small proportion of the 1035 commercially produced assays that we identified on the FIND website in January 2024 [17].

7. Limited evidence for any effect by age in asymptomatic populations

Our previous review iteration suggested possibly lower Ag-RDT sensitivity in children compared to adults. Restricting to within-study comparisons of test use in children compared to adults, we found no evidence of a meaningful difference in asymptomatic populations (sensitivity 5.7 percentage points higher in adults compared to in children (95% CI from -6.0 to 17.5 percentage points)).

8. Secondary analyses by vaccination status, prior SARS-COV-2 infection and SARS-CoV-2 variant

A total of 18 studies that reported data on mixed, mostly asymptomatic participants also reported data for the effect of age, vaccination status, prior SARS-COV-2 infection and SARS-CoV-2 variant, regardless of symptom status.

Results suggested no clinically meaningful difference in average sensitivity according to vaccination status but a potentially lower specificity in those who were vaccinated compared to those who were not. The difference was only 0.4 percentage points; however, even such small differences can have important effects at very low prevalences of SARS-CoV-2 infection. Average sensitivity was considerably higher (21.8 percentage points) in those who reported no prior SARS-CoV-2 infection; however, the number of cases reporting a prior infection was much smaller than those with no infection and studies were highly heterogeneous, such that 95% CIs for the difference ranged from 6.9 to 36.7 percentage points.

Only limited evidence was available for the SARS-CoV-2 variant, partly because of the search cut-off for this review but also because of the exclusion of studies of analytical accuracy which, may be a more appropriate and more controlled way of identifying true differences in test performance for different variants. Reviews with more recent search dates (e.g. Manten (2024) [264], search cut-off November 2022) have attempted to consider antigen RDT accuracy according to the SARS-CoV-2 variant. Manten and colleagues suggested that RDT sensitivity was highest at 78.2% (95% CI 74.7 to 85.5) when the wild-type SARS CoV-2 was predominant (64 data sets, sensitivity 78.2%), remained above 70% when the Delta variant became prevalent (6 datasets), but appeared to drop to 54.8% for the Alpha variant (10 datasets). The authors reported data for only two studies conducted when Omicron was prevalent, both of which reported sensitivities of over 75% [264]. Most of the data in this review were from symptomatic participants. The review authors were unable to draw conclusions about the effect of different variants on accuracy due to substantial between-study heterogeneity [264].

Illustration of the predicted effect of antigen testing by symptom status

Below we illustrate predicted numbers of true positives, false positives, false negatives and true negatives, applying summary estimates of test accuracy to a hypothetical cohort of asymptomatic people suspected of SARS-CoV-2 infection across a range in prevalence of SARS-CoV-2 infection (Summary of findings 1).

We illustrate effects for two subgroups: testing reported to be widely available to any asymptomatic person with no requirement to meet pre-set criteria for testing (sensitivity 53.0%, 95% CI 48.4% to 57.5%, and specificity 99.6%, 95% CI 99.5% to 99.6%) and testing restricted to those reporting epidemiological exposure (contacts of confirmed cases) to COVID-19 (sensitivity 58.6%, 95% CI 51.4% to 65.6%, and specificity 99.4%, 95% CI 99.2% to 99.5%). The average values were applied to a cohort of 10,000 people asymptomatic for COVID-19, with a prevalence of 0.5% in whom 50 people had confirmed infection:

- 67 (widely available) or 89 (epidemiological exposure) individuals would have a positive test result, of which 40 and 60 would be false positives (PPVs of 40% and 33%, respectively); and
- 24 (widely available) and 21 (epidemiological exposure) people with negative test results would be falsely negative (NPVs both 99.8%).

At such a low prevalence of infection, the estimated number of cases missed is only marginally affected by the confidence intervals around the average sensitivity estimates (e.g. ranging from 21 to 26 where testing was widely available). If the prevalence of infection increased to 2% from 0.5%, the number of cases missed for every 10,000 people tested would range from 85 to 103 where testing was widely available and 69 to 97 for testing contacts of confirmed cases.

In contrast, although the 95% CIs for average specificities were only 0.1 to 0.3 percentage points wide, the absolute numbers of false positives at a disease prevalence of 0.5%, ranged between 40 and 50 for widely available testing and from 50 to 80 for testing contacts of confirmed cases. The number of false positives were only marginally affected by small changes in prevalence; however, PPVs increased to 73% and 67%, respectively (Summary of findings 1).

Strengths and weaknesses of the review

Our review used a broad search, screening all articles concerning COVID-19 or SARS-CoV-2. We undertook all screening and eligibility assessments, QUADAS-2 assessments [55], and data extraction of study findings independently and in duplicate. Although it is possible that the use of artificial intelligence text analysis to identify studies most relevant to diagnostic questions may have led to some eligible studies being missed, we believe that the multi-stranded search strategy used will have identified most, if not all relevant literature. Whilst we have reasonable confidence in the completeness and accuracy of the findings up until the search date, should errors be noted please inform us at coviddta@contacts.bham.ac.uk.

The review is limited by the length of time elapsed between the last search (February 2022) and the publication of the review. Although we cannot quantify the number of eligible studies that have been published during the interim period, we have conducted a scoping search to identify any systematic reviews on the same topic published since the search cut-off date. We identified a total of 17 reviews, none of which focused on RDT accuracy in asymptomatic populations. Although several reviews did report RDT accuracy in subgroups of asymptomatic participants, the largest dataset reported was for 72,547 asymptomatic participants from 57 studies in a review with a search cut-off of August 2021 (265). The review with the latest search cut-off date was by Hirabayashi and colleagues comparing RDT accuracy against a viral genetic test reference standard; only 11 datasets from asymptomatic participants were included (266). Our review therefore adds considerable value, despite the time elapsed since the search was performed. Furthermore, although our dataset was more than three times larger than was included in our previous review iteration, which had a search cut-off of March 2021 (144,250 samples compared to 41,129 [4]) only marginal changes in average summary sensitivity and specificity estimates and similar patterns of effects by subgroup were observed. It is likely that inclusion of further evidence will primarily lead to a further narrowing of confidence intervals rather than to changes in our conclusions about the accuracy of Ag-RDTs in asymptomatic populations.

We have previously discussed in some detail the limitations of RT-PCR as a reference standard for COVID-19, particularly in regard to the use of Ct values as a proxy for 'infectiousness' ([4]). In summary, the suitability of RT-PCR Ct values for this purpose is limited for a number of reasons. These reasons include: variability between laboratories (267) and in sample collection and processing (268), so that comparison at fixed Ct values is unlikely to be comparable across studies; the use of different and potentially suboptimal methods of calculating viral load from Ct values can introduce variability in results (14); the inverse relationship between viral load and risk of infecting others is a continuum of risk, with no meaningful cut-point indicating infectious versus not infectious (269); and finally even the most precise estimation of viral load cannot determine whether an individual is at the onset of infection and therefore likely to be infectious for a period of time or is recovering from infection and has declining viral load. The latter reason is particularly key for testing people with no signs or symptoms of COVID-19.

We did not consider the repeated use of antigen tests in different asymptomatic groups, such as school children and staff, hospital and care home workers. Our previous review iteration identified only four eligible studies evaluating the accuracy of repeated testing; these varied in purpose, design, testing strategies and presentation of results such that it was not possible to make generalisations about the value of repeated testing strategies. A more appropriate approach to evaluation of repeated testing is to consider the *effectiveness* of screening asymptomatic individuals to limit the *transmission* of SARS-CoV-2, as was reported in a 2021 rapid review [270]. A total of 16 studies were included in the review; eight examined the effectiveness of Ag-RDTs for population level screening, four for pre-event screening and four for repeated testing of asymptomatic individuals over time. Overall, the review identified considerable heterogeneity between studies and concerns about methodological quality, such that there is uncertainty regarding the effectiveness of screening asymptomatic individuals with Ag-RDTs to limit the transmission of SARS-CoV-2.

Considerable improvements in study quality were observed for this review iteration. Reporting of key aspects of study design and execution remains relatively poor, however, especially for application of the reference standard and participant flow domains. In order to include data for all tests in meta-analyses, we also had to include some samples multiple times. We have been explicit about these issues where they arose.

We are aware of a few other systematic reviews of Ag-RDTs published since our last review iteration, none of which focus specifically on testing asymptomatic people. Two reviews reported an earlier search cut-off compared to this review [271; 272], and one with a later cut-off date of May 2022 included only 60 studies in asymptomatic people [273]. Our review therefore includes a much higher number of samples from asymptomatic participants, and has allowed us to conduct a more detailed analysis using the study setting and indication for testing.

Applicability of findings to the review question

We previously recommended that Ag-RDT performance should be assessed according to the use case for which these assays are being considered. Our review has allowed us to consider Ag-RDT performance in a number of different settings and indications for testing, suggesting higher sensitivity when used in individuals likely to have had a recent epidemiological exposure to a confirmed case, or in asymptomatic individuals presenting for testing at COVID-19 test centres, compared to assay use in screening scenarios where asymptomatic individuals are tested regardless of epidemiological indications. Lower sensitivities in the latter group will be affected by a number of factors, including likelihood of exposure, time spent in contact with SARS-COV-2 cases, and time since exposure to infection.

It is notable that the majority of studies were conducted in Europe or North America, and it is not clear whether results will fully generalise to low- or middle-income countries.

As noted in our previous review iteration, incomplete symptom assessment and lack of adequate follow-up to identify subsequent development of symptoms or previous history of symptoms can all contribute to inappropriate classification of individuals as having asymptomatic infection [274]. Although we have been able to consider the effect of the study setting and indication for testing in more detail than previously, the estimates for test accuracy primarily represent accuracy in those without clearly defined symptoms at the time of testing.

AUTHORS' CONCLUSIONS

Implications for practice

Sensitivity was consistently low in asymptomatic populations with relatively narrow confidence intervals. We found some suggestion that sensitivity was higher in people with a known exposure to SARS-CoV-2 compared to testing scenarios that reflect screening of asymptomatic individuals. Because of the reliance on RT-PCR, there is not a reliable reference standard for the identification of 'infectiousness'. We are therefore unable to identify whether those studies using Ag-RDTs for screening purposes successfully identified individuals who were infectious at the time of testing Ag-RDT and who require isolation, and those who provide no risk. The effectiveness of using these tests for screening purposes will only be established though participant outcome studies, such as cluster-randomised community trials.

Nevertheless, Ag-RDTs that demonstrate the highest specificities (i.e. 99% and above) should be considered for testing asymptomatic individuals during a period of outbreak or in those with likely exposure to SARS-CoV-2 (i.e. higher prevalence scenarios), as those found testing positive will have a higher chance of being true positives, requiring isolation. Consideration should be made, considering whether Ag-RDT positives should be confirmed with RT-PCR to identify false positives. With a 1% prevalence, and using average sensitivity and specificity for those likely to be contacts of confirmed cases, as much as half of those with positive results would be falsely positive. Using accuracy data more likely to represent screening scenarios, at 1% prevalence, on average, RDTs yield false positives at a ratio of more than 2:3 (PPV 57%), and at 0.5% prevalence, false positives more than outweigh true positives (PPV 40%) even for tests with greater than 99% specificity (Summary of findings 1).

Although in a screening-type context, the overriding need is typically for tests with high specificities that minimise the effect of false positive findings, for infectious diseases like COVID-19, the impact on onward transmission rates from false negative findings cannot be understated. Studies of daily RDT testing have suggested suboptimal detection rates compared to PCR in the days leading up to onset of symptoms [275], and further, that even daily RDT testing may not be sufficient to contain transmission [276]. With accumulating evidence that RDTs on average have lower sensitivities when evaluated in independent field studies compared to manufacturer-funded studies [277, 278], where asymptomatic testing is deployed, efforts should be made to identify and validate RDTs with higher sensitivities in an asymptomatic population.

Overall, our conclusions have strengthened those from the previous version of this review and allowed some consideration of test accuracy in different testing scenarios. Ultimately, decisions around rapid testing will be driven not only by diagnostic accuracy but by acceptable levels of test complexity, time to result, access to testing and acceptability to those being tested, and how test results influence individual behaviour, all of which might vary according to the setting in which the tests are to be used.

Implications for research

There is now a considerable volume of research for point-of-care tests for SARS-CoV-2 infection in asymptomatic populations. Nevertheless, evidence for the clinical performance of many test brands is scarce or lacking, and well-designed prospective and comparative evaluations of different test brands in clinically relevant settings (both for symptomatic and asymptomatic testing) are still needed. Studies should recruit consecutive series of eligible participants and should clearly describe the clinical status, document time from symptom onset, or time since exposure. Point-of-care tests must be conducted in accordance with manufacturer instructions for use, and across the spectrum of point-of-care settings and test operators. Evaluations of both individual tests and strategies of repeated testing are needed. Given the reliance of asymptomatic testing strategies on unsupervised self-testing, further research on the accuracy and usability of self-testing using rapid antigen tests is needed, with improved user education to minimise errors and false reassurance.

The establishment of an international reference standard for SARS-COV-2, such as those developed by the WHO (e.g. 279), would go some way to reducing variability in RT-PCR assays.

Consideration needs to be made of the best method for evaluating screening programmes, whether mass screening or targeted approaches, including schools, healthcare setting and traveller screening. Whilst test accuracy studies help indicate which tests are likely to detect the greatest numbers of cases with the fewest false positives, assessing whether detecting asymptomatic cases leads to worthwhile reductions in disease spread will only be properly answered by studies of impact not accuracy.

Manufacturers and independent investigators are strongly encouraged to consider the principles for test evaluation set out by the Royal Statistical Society Diagnostic Tests Working Group [280].

Any future research study needs to be clear about eligibility and exclusion decisions throughout the whole diagnostic pathway, and should conform to the updated Standards for Reporting of Diagnostic Accuracy (STARD) guideline [281].

SUPPLEMENTARY MATERIALS

Supplementary materials are available with the online version of this article: 10.1002/14651858.CD013705.pub4.

Supplementary material 1 Search strategies

Supplementary material 2 Characteristics of included studies

Supplementary material 3 Characteristics of excluded studies

Supplementary material 4 Analyses

Supplementary material 5 Data package

Supplementary material 6 Reference standards for SARS-CoV-2

Supplementary material 7 Definition of 'point of care' used in this review

Supplementary material 8 Data extraction items

Supplementary material 9 Criteria for assessment of study quality (QUADAS-2)

Supplementary material 10 Summary study characteristics

Supplementary material 11 Summary index test details

Supplementary material 12 Index test details from manufacturer instructions for use documents

Supplementary material 13 Methodological quality by domain for individual studies

Supplementary material 14 Results of meta-analysis including additional 'sensitivity-only' or 'specificity only

Supplementary material 15 Additional forest plots of data for subgroup analyses

Supplementary material 16 Table of results of analyses by test brand (all in asymptomatic or mainly asymptomatic cohorts of participants)

Supplementary material 17 Forest plots of data by test brand

Supplementary material 18 Results of meta-analysis by test brand and within-study comparisons by test brand

Supplementary material 19 Table of results of secondary analyses regardless of symptom status

Supplementary material 20 Forest plots of data for secondary analyses (including symptomatic participants)

ADDITIONAL INFORMATION

Acknowledgements

Thank you to all authors who contributed to one or more previous iterations of this living review (published 2020 and 2021) and the wider team of systematic reviewers from the University of Birmingham, UK who assisted with title and abstract screening across the entire suite of reviews for the diagnosis of COVID-19 prior to the publication of the first iteration of this review.

Thank you to Pawana Sharma of ICON plc who assisted with screening, data extraction and quality assessment of included studies while employed by the University of Birmingham, UK and who co-authored the previous two iterations of this review (published 2022 and 2021).

Editorial and peer review contributions

The Cochrane Infectious Diseases Group (CIDG) supported the authors in the development of this diagnostic test accuracy review. The CIDG editorial base was funded by UK aid from the UK government for the benefit of low- and middle-income countries (project number 300342-104) up to December 2024. The views expressed do not necessarily reflect the UK government's official policies.

The following people conducted the editorial process for this article.

- Sign-off Editor (final editorial decision): Michael D Brown, Michigan State University;
- Managing Editor (selected peer reviewers, collated peer-reviewer comments, provided editorial guidance to authors, edited the article): Joanne Duffield, Central Editorial Service;
- Editorial Assistant (conducted editorial policy checks and supported the editorial team): Hannah Payne, Central Editorial Service;
- Copy Editor (copy editing and production): Anne Lethaby, Cochrane Central Production Service;
- Peer-reviewers (provided comments and recommended an editorial decision): Dr Deonna Ackermann, Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Australia (clinical/content review), Vivienne C. Bachelet, Universidad de Santiago de Chile (clinical/content review), Manuel Krone, University Hospital Würzburg, Germany (clinical/content review), Cheryl Sumner (patient and public involvement review), Sofia Tsokani, Methods Support Unit, Cochrane CET (methods review), Jo Platt, Central Editorial Information Specialist (search review). One additional peer reviewer provided clinical/content peer review, but chose not to be publicly acknowledged.

Contributions of authors

JDi was the contact person with the editorial base.
JDi co-ordinated contributions from the co-authors and wrote the final draft of the review.
JDi, JW, PR, AD screened papers against eligibility criteria.
RS conducted the literature searches.
JDi, JW, PR, AD, SvW, NN, CD, MT, DW, DH, BH, KS, YM, FI, PW appraised the quality of papers.
JDi, JW, PR, AD, SvW, NN, CD, MT, DW, DH, BH, KS, YM, FI, PW extracted data for the review and sought additional information about papers.
JDi entered data into RevMan [282].
JDi, SB, JJD, YT, CD analysed and interpreted data.
JDi, JJD, YT, CD, STP, RS, ML, MM, LH, AVB, DE, SD, JC, JV worked on the methods sections.

JDi, SB, JW, PR, AD, BH, KS, DH, FI, YM, NN, MT, PW, SvW, JC, CD, SD, DE, LH, ML, MM, RS, JV, YT, STP, AVB, JJD commented on the draft review.
JDi, JJD responded to the comments of the referees.
JDi is the guarantor of the update.

Declarations of interest

Jacqueline Dinnes: declares a grant from Evidence Synthesis Ireland (ESI) Fellowship agreement to supervise three fellows contributing to this review (paid to institution; JD does not benefit financially). JD is an Editor for the Cochrane DTA Editorial Team. She was not involved in the editorial process for this review. JD has published opinions on the topic: (1) Dinnes J, Davenport C. COVID-19 rapid antigen testing strategies must be evaluated in intended use settings. Lancet Regional Health Western Pacific 2022;25:100542. doi: 10.1016/j.lanwpc.2022.100542; (2) Deeks JJ, Dinnes J, Davenport C, Takwoingi Y, McInnes M, Leeflang MM, et al. Letter to the Editor regarding Peto T; UK COVID-19 Lateral Flow Oversight Team: COVID-19: Rapid antigen detection for SARS-CoV-2 by lateral flow assay. EClinicalMedicine 2021;38; (3) Dinnes J. COVID-19 rapid antigen testing strategies require careful evaluation. EBioMedicine 2021;70:103491; (4) Dinnes J, Davenport C. Do we have informed consent for asymptomatic COVID-19 testing in schools? BMJ opinion. https://blogs.bmj.com/bmj/2021/03/16/do-we-have-informed-consent-for-asymptomatic-testing-in-schools/, 2021.

Sarah Berhane: none known.

Jennifer Walsh works as a Consultant Microbiologist at Cork University Hospital. She has no known conflicts to declare.

Paul Reidy works as a health professional at Trinity College Dublin. He has no known conflicts to declare.

Aaron Doherty works as a Consultant Clinical Microbiologist, Cork University Hospital (HSE). At the time of writing this review, he was employed at UCD National Virus Reference Laboratory, Dublin, Ireland. He has no known conflicts to declare.

Bethany Hillier: none known

Katie Scandrett: none known

Dineshani Hettiarachchi: none known

Fahmida Islam: none known.

Praveen Weeratunga: none known

Yasith Mathangasinghe: none known

Nicholas Nyaaba works as General Nurse at the Connolly Hospital. At the time of writing this review, he was employed at 37 Military Hospital, Cantonments, Ghana. He has no known conflicts to declare.

Melissa Taylor: none known

Dakshithaw Wickramasinghe: none known

Susan van Wyk: none known

Jane Cunningham: no relevant interests; affiliated to WHO, which produces guidance on use of SARS-CoV-2 rapid tests.

Clare Davenport: no relevant interests. CD is a Senior Editor for the Cochrane Central Editorial Service. She was not involved in the editorial process for this review.

Sabine Dittrich: was employed by FIND (until June 2022 as part of senior management; 2024 consultancy to advise on grant writing activities), with funding from DFID and Australian Aid.

FIND is a global not-for profit product development partnership and WHO Diagnostic Collaboration Centre. It is FIND's role to accelerate access to high-quality diagnostic tools for low-resource settings and this is achieved by supporting both research and development and access activities for a wide range of diseases, including COVID-19. FIND has several clinical research projects to evaluate multiple new diagnostic tests against published Target Product Profiles that have been defined through consensus processes. These studies are for diagnostic products developed by private sector companies who provide access to know-how, equipment/reagents, and contribute through unrestricted donations as per FIND policy and external SAC review.

Devy Emperador: was employed by FIND, with funding from FCDO and CAN, during the write-up of this review.

Lotty Hooft: no relevant interests. LH is a Professor of Evidence Synthesis & Knowledge Translation in Healthcare at Universitair Medisch Centrum Utrecht, and a member of the DTA Editorial Team and PMG implementation team. She was not involved in the editorial process for this review.

Mariska Leeflang: no relevant interests. ML is an Associate Professor at Academisch Medisch Centrum, and Contact Editor for the Cochrane DTA Editorial Team. She was not involved in the editorial process for this review. ML also declares a grant from Cochrane for finalising the DTA Handbook, on which she is an Editor and active proponent, and royalties from the sale of the Handbook (personal payment). ML also reports personal payment for expert testimony.

Matthew McInnes: none known. MMI is a Physician at Ottawa Hospital.

Rene Spijker: none known. RS is employed as an Information Specialist/Senior Scientist for three days per week at AmsterdamUMC. For two days per week, he is seconded to Cochrane Netherlands, which is hosted at Universitair Medisch Centrum, Utrecht. He was not involved in the editorial process for this review.

Jan Verbakel: none known

Yemisi Takwoingi: no relevant interests. YT declares that she is a member of the Cochrane Editorial Board. She was not involved in the editorial process for this review.

Sian Taylor-Phillips: ST-P is Chair of the UK National Screening Committee Research Methodology Group and a Data Scientist Member of the UK National Screening Committee. ST-P holds an NIHR Research Professorship (NIHR302434), looking at how to accurately bring together different sources of research evidence to support policy decisions, and an NIHR Career Development Fellowship (NIHR-CDF-2016-018) for methods of

evaluating screening tests **(**paid to University of Warwick, though ST-P benefitted). ST-P also declares funding from Birmingham University (originally from FIND diagnostics, a charity) to fund a staff member to work on this review (approximately six months part-time); paid to Warwick University. ST-P is a co-author on the EDSAB-HOME study, which was funded by Public Health England; however, neither she nor her institution received funds for participating in that study.

Ann Van den Bruel: no relevant interests.

Jonathan Deeks: JD has published or been quoted in opinion pieces in scientific publications, and in the mainstream and social media related to diagnostic testing. JD was the statistician on the Birmingham evaluation of the Innova test (Ferguson 2021). There was no funding for this evaluation of the Innova test. JD is a Member of the Royal Statistical Society (RSS) COVID-19 Taskforce Working group, and Co-Chair of the RSS Diagnostic Test Working Advisory Group (unpaid positions). JD is an Editor for the Cochrane DTA Editorial Team. He was not involved in the editorial process for this review.

Sources of support

Internal sources

- University of Birmingham, UK

  The lead author (JD) and seven co-authors of this review (SB, BH, KS, CD, YT, JJD) are employees of the University of Bimingham
- Liverpool School of Tropical Medicine, UK

  LSTM hosted the Cochrane Infectious Diseases Group (CIDG) up to December 2024, which supported the authors in the development of this diagnostic test accuracy review

External sources

- National Institute for Health Research (NIHR), UK

  Sian Taylor-Phillips was supported by an NIHR Career Development Fellowship NIHR-CDF-2016-018 for methods of evaluating screening tests. Jonathan Deeks is a UK NIHR Senior Investigator Emeritus
- NIHR Birmingham Biomedical Research Centre at the University Hospitals Birmingham NHS Foundation Trust and the University of Birmingham, UK

  Jacqueline Dinnes, Sarah Berhane, Clare Davenport, Yemisi Takwoingi and Jonathan Deeks were supported by the National Institute for Health and Care Research (NIHR) Birmingham Biomedical Research Centre (BRC). This paper presents independent research supported by the NIHR Birmingham BRC at the University Hospitals Birmingham NHS Foundation Trust and the University of Birmingham. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care
- Foreign, Commonwealth, and Development Office (FCDO), UK

  Project number: 300342-104
- Evidence Synthesis Ireland Fellowship Scheme, National University of Ireland, Galway, Ireland

  Aaron Doherty, Paul Reidy and Jennifer Walsh were supported by the Irish Health Research Board and the HSC Public Health Agency (Grant number CBES-2018-001) in association with Evidence Synthesis Ireland/Cochrane Ireland

Registration and protocol

Protocol (2020) DOI 10.1002/14651858.CD013596

Original Review (2020) DOI 10.1002/14651858.CD013705

Review Update 1 (2021) DOI 10.1002/14651858.CD013705.pub2

Review Update 2 (2022) DOI 10.1002/14651858.CD013705.pub3

Data, code and other materials

As part of the published Cochrane Review, the following is made available for download for users of the Cochrane Library (see Supplementary material 5): Full search strategies for each database (Supplementary material 1); full citations of each unique report for all studies included or excluded at the full-text screen, in the final review; study data, including study information, test data (see Supplementary material 2; Supplementary material 3); consensus risk of bias assessments (see Supplementary material 2); and analysis data, including overall estimates and settings, subgroup estimates, and individual data rows (see Table 2, and Supplementary material 14; Supplementary material 16; Supplementary material 18; Supplementary material 19). Analyses and data management were conducted using Excel and STATA/SE 18.0 [58]. Template data extraction forms from Excel are available from the authors on reasonable request. See Cochrane's policy on data sharing: https://www.cochranelibrary.com/cdsr/editorial-policies#data.

What's new

Date	Event	Description
28 November 2025	New search has been performed	Targeted update with evidence for asymptomatic populations published between March 2021 and February 2022. Methods amended accordingly to focus only on data for asymptomatic participants. Author byline amended to include additional co-authors and remove co-authors who did not contribute to this review update.

Date	Event	Description
28 November 2025	New citation required but conclusions have not changed	Conclusions from previous review iteration for accuracy in asymptomatic partipants have been further strengthened with the addition of new studies.

History

Review first published: Issue 8, 2020

Date	Event	Description
21 July 2022	New citation required and conclusions have changed	New evidence incorporated; evidence for testing in asymptomatic cohorts has increased.
21 July 2022	New search has been performed	Updated with evidence published between September 2020 and March 2021.
10 January 2022	New search has been performed	Review updated with search until 18 March 2021.
15 April 2021	Amended	Clarification in Appendices that isothermal amplification is not a RT-PCR test.
24 March 2021	Amended	Correction of typo in abstract
24 March 2021	Amended	Amendment to PLS title
9 March 2021	New citation required and conclusions have changed	This review has been updated and the conclusions have changed
30 September 2020	New search has been performed	We have updated our review and now include 64 study reports in 78 study cohorts, evaluating 16 antigen and 5 molecular assays

REFERENCES

1. Struyf T, Deeks JJ, Dinnes J, Takwoingi Y, Davenport C, Leeflang MM, et al. Signs and symptoms to determine if a patient presenting in primary care or hospital outpatient settings has COVID-19. *Cochrane Database of Systematic Reviews* 2021, Issue 2. Art. No: CD013665. [DOI: 10.1002/14651858.CD013665.pub2]

2. Stegeman I, Ochodo EA, Guleid F, Holtman G, Yang B, Cunningham J, et al. Routine laboratory testing to determine if a patient has COVID-19. *Cochrane Database of Systematic Reviews* 2020, Issue 11. Art. No: CD013787. [DOI: 10.1002/14651858.CD013787]

3. Ebrahimzadeh S, Islam N, Dawit H, Salameh JP, Kazi S, Fabiano N, et al. Thoracic imaging tests for the diagnosis of COVID-19. *Cochrane Database of Systematic Reviews* 2022, Issue 5. Art. No: CD013639. [DOI: 10.1002/14651858.CD013639.pub5]

4. Dinnes J, Sharma P, Berhane S, Van Wyk SS, Nyaaba N, Domen J, et al. Rapid, point-of-care antigen tests for diagnosis of SARS-CoV-2 infection. *Cochrane Database of Systematic Reviews* 2022, Issue 7. Art. No: CD013705. [DOI: 10.1002/14651858.CD013705.pub3]

5. Fox T, Geppert J, Dinnes J, Scandrett K, Bigio J, Sulis G, et al. Antibody tests for identification of current and past infection with SARS-CoV-2. *Cochrane Database of Systematic Reviews* 2022, Issue 11. Art. No: CD013652. [DOI: 10.1002/14651858.CD013652.pub2]

6. FIND. Impact of variants on COVID-19 tests. www.finddx.org/covid-19/impact-of-variants-on-covid19-tests/ (accessed 6 January 2022).

7. Dinnes J, Deeks JJ, Adriano A, Berhane S, Davenport C, Dittrich S, et al. Rapid, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection. *Cochrane Database of Systematic Reviews* 2020, Issue 8. Art. No: CD013705. [DOI: 10.1002/14651858.CD013705]

8. Dinnes J, Deeks JJ, Berhane S, Taylor M, Adriano A, Davenport C, et al. Rapid, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection. *Cochrane Database of Systematic Reviews* 2021, Issue 3. Art. No: CD013705. [DOI: 10.1002/14651858.CD013705.pub2]

9. Mathieu E, Appel C, Rodés-Guirao L. Ending our COVID-19 testing data updates. ourworldindata.org/covid-testing-data-archived [accessed 25-03-2024] 2022 (accessed prior to 9 October 2025).

10. European Centre for Disease Prevention and Control (ECDC). Data on testing for COVID-19 by week and country; 17-11-2023. www.ecdc.europa.eu/en/publications-data/covid-19-testing (accessed 25 March 2024).

11. Africa CDC COVID-19 Dashboard; 01-03-2023. africacdc.maps.arcgis.com/apps/dashboards/a5603222b29c49539df3af45bac16bcc (accessed 25 March 2024).

12. UK Health Security Agency. [Withdrawn] Guidance for contacts of people with confirmed coronavirus (COVID-19) infection who do not live with the person; 15 February 2022. www.gov.uk/government/publications/guidance-for-contacts-of-people-with-possible-or-confirmed-coronavirus-covid-19-infection-who-do-not-live-with-the-person/guidance-for-contacts-of-people-with-possible-or-confirmed-coronavirus-covid-19-infection-who-do-not-live-with-the-person 2022 (accessed 25 March 2024).

13. UK Health Security Agency. People with symptoms of a respiratory infection including COVID-19; 10 June 2022. www.gov.uk/guidance/people-with-symptoms-of-a-respiratory-infection-including-covid-19 2022 (accessed 25 March 2024).

14. Evans D, Cowen S, Kammel M, O'Sullivan DM, Stewart G, Grunert H-P, et al. The dangers of using Cq to quantify nucleic acid in biological samples: a lesson from COVID-19. *Clinical Chemistry* 2021;**68**(1):153-62.

15. Jiang N, Tansukawat ND, Gonzalez-Macia L, Ates HC, Dincer C, Güder F, et al. Low-cost optical assays for point-of-care diagnosis in resource-limited settings. *ACS Sensors* 2021;**6**(6):2108-24.

16. Noel RH. Speed meets sensitivity to limit infectious spread in rapid microfluidic antigen testing. www.mlo-online.com/diagnostics/article/21222539/speed-meets-sensitivity-to-limit-infectious-spread-in-rapid-microfluidic-antigen-testing; 19 May 2021 (accessed prior to 9 October 2025).

17. FIND. SARS-COV-2 diagnostic pipeline. www.finddx.org/covid-19/pipeline/ (accessed 5 January 2022).

18. Frnda J, Durica M. On pilot massive COVID-19 testing by antigen tests in Europe. Case study: Slovakia. *Infectious Disease Reports* 2021;**13**(1):45-57. [DOI: 10.3390/idr13010007]

19. Garcia-Finana M, Hughes DM, Cheyne CP, Burnside G, Stockbridge M, Fowler TA, et al. Performance of the Innova SARS-CoV-2 antigen rapid lateral flow test in the Liverpool asymptomatic testing pilot: population based cohort study. *BMJ (Clinical Research Ed.)* 2021;**374**:n1637.

20. Green K, Graziadio S, Turner P, Fanshawe T, Allen J; Oxford COVID-19 Evidence Service Team Centre. Molecular and antibody point-of-care tests to support the screening, diagnosis and monitoring of COVID-19. www.cebm.net/oxford-covid-19/ (7 April 2020) 2020 (accessed prior to 9 October 2025).

21. Kozel TR, Burnham-Marusich AR. Point-of-care testing for infectious diseases: past, present, and future. *Journal of Clinical Microbiology* 2017;**55**(8):2313-20. [DOI: 10.1128/JCM.00476-17]

22. Lai CK, Lam W. Laboratory testing for the diagnosis of COVID-19. *Biochemical and Biophysical Research Communications* 2021;**538**:226-30.

23. Deeks JJ, Dinnes J, Takwoingi Y, Davenport C, Leeflang MM, Spijker R, et al. Diagnosis of SARS-CoV-2 infection and COVID-19: accuracy of signs and symptoms; molecular, antigen, and antibody tests; and routine laboratory markers. *Cochrane Database of Systematic Reviews* 2020, Issue 4. Art. No: CD013596. [DOI: 10.1002/14651858.CD013596]

24. Deeks JJ, Dinnes J, Takwoingi Y, Davenport C, Spijker R, Taylor-Phillips S, et al. Antibody tests for identification of current and past infection with SARS-CoV-2. *Cochrane Database of Systematic Reviews* 2020, Issue 6. Art. No: CD013652. [DOI: 10.1002/14651858.CD013652]

25. COVID-19 Open Access Project. Living Evidence on COVID-19. ispmbern.github.io/covid-19/living-review/ 2021 (accessed prior to 9 October 2025).

26. Covidence. Version accessed 27 April 2020. Melbourne, Australia: Veritas Health Innovation, 2020. Available at covidence.org.

27. Abusrewil Z, Alhudiri IM, Kaal HH, El Meshri SE, Ebrahim FO, Dalyoum T, et al. Time scale performance of rapid antigen testing for SARS-COV-2: evaluation of ten rapid antigen assays. *Journal of Medical Virology* 2021;**93**(12):6512-8. [DOI: 10.1002/jmv.27186]

28. Aleem S, Zahoor N, Jeelani A, SalimKhan SM. Diagnostic accuracy of STANDARD QCOVID-19 antigen detection kit in comparison with RT-PCR assay using nasopharyngeal samples in India. *Journal of Clinical and Diagnostic Research* 2022;**16**(1):DC01-5. [DOI: 10.7860/JCDR/2022/52286.15825]

29. Almendares O, Prince-Guerra JL, Nolen LD, Gunn JK, Dale AP, Buono SA, et al. Performance characteristics of the Abbott BinaxNOW SARS-CoV-2 antigen test in comparison to real-time RT-PCR and viral culture in community testing sites during November 2020. *Journal of Clinical Microbiology* 2022;**60**(1):e0174221. [DOI: 10.1128/JCM.01742-21]

30. Andreani J, Lupo J, Germi R, Laugier C, Roccon M, Larrat S, et al. Evaluation of six commercial SARS-CoV-2 rapid antigen tests in nasopharyngeal swabs: Better knowledge for better patient management? [Evaluation of six commercial SARS-CoV-2 rapid antigen tests in nasopharyngeal swabs: better knowledge for better patient management?]. *Journal of Clinical Virology* 2021;**143**:104947. [DOI: 10.1016/j.jcv.2021.104947]

31. Bianco G, Boattini M, Barbui AM, Scozzari G, Riccardini F, Coggiola M, et al. Evaluation of an antigen-based test for hospital point-of-care diagnosis of SARS-CoV-2 infection. *Journal of Clinical Virology* 2021;**139**:104838.

32. Burdino E, Cerutti F, Panero F, Allice T, Gregori G, Milia MG, et al. SARS-CoV-2 microfluidic antigen point-of-care testing in Emergency Room patients during COVID-19 pandemic. *Journal of Virological Methods* 2022;**299**:114337. [DOI: 10.1016/j.jviromet.2021.114337]

33. Caramello V, Boccuzzi A, Basile V, Ferraro A, Macciotta A, Catalano A, et al. Are antigenic tests useful for detecting SARS-CoV-2 infections in patients accessing to emergency departments? Results from a North-West Italy hospital. Journal of Infection 2021;**83**(2):237-79. [1532-2742: (Electronic)]

34. Dankova Z, Novakova E, Skerenova M, Holubekova V, Lucansky V, Dvorska D, et al. Comparison of sars-cov-2 detection by rapid antigen and by three commercial rt-qpcr tests: A study from martin university hospital in Slovakia [Comparison of sars-cov-2 detection by rapid antigen and by three commercial rt-qpcr tests: a study from martin university hospital in slovakia]. *International Journal of Environmental Research and Public Health* 2021;**18**(13):10.3390/ijerph18137037. [DOI: 10.3390/ijerph18137037]

35. Denina M, Giannone V, Curtoni A, Zanotto E, Garazzino S, Urbino AF, et al. Can we trust in Sars-CoV-2 rapid antigen testing? Preliminary results from a paediatric cohort in the emergency department. Irish Journal of Medical Science 202110.1007/s11845-021-02776-z.

36. Dierks S, Bader O, Schwanbeck J, Gross U, Weig MS, Mese K, et al. Diagnosing sars-cov-2 with antigen testing, transcription-mediated amplification and real-time pcr [Diagnosing sars-cov-2 with antigen testing, transcription-mediated amplification and real-time pcr]. *Journal of Clinical Medicine* 2021;**10**(11):10.3390/jcm10112404. [DOI: 10.3390/jcm10112404]

37. Frediani JK, Levy JM, Rao A, Bassit L, Figueroa J, Vos MB, et al. Multidisciplinary assessment of the Abbott BinaxNOW SARS-CoV-2 point-of-care antigen test in the context of emerging viral variants and self-administration [Multidisciplinary assessment of the Abbott BinaxNOW SARS-CoV-2 point-of-care antigen test in the context of emerging viral variants and self-administration]. *Scientific Reports* 2021;**11**(1):14604. [DOI: 10.1038/s41598-021-94055-1]

38. Hirotsu Y, Sugiura H, Maejima M, Hayakawa M, Mochizuki H, Tsutsui T, et al. Comparison of Roche and Lumipulse quantitative SARS-CoV-2 antigen test performance using automated systems for the diagnosis of COVID-19 [Comparison of Roche and Lumipulse quantitative SARS-CoV-2 antigen test performance using automated systems for the diagnosis of COVID-19]. *International Journal of Infectious Diseases* 2021;**108**:263-9. [DOI: 10.1016/j.ijid.2021.05.067]

39. Kiro VV, Gupta A, Singh P, Sharad N, Khurana S, Prakash S, et al. Evaluation of COVID-19 antigen fluorescence immunoassay test for rapid detection of SARS-cov-2 [Evaluation of COVID-19 Antigen Fluorescence Immunoassay Test for Rapid Detection of SARS-CoV-2]. *Journal of Global Infectious Diseases* 2021;**13**(2):91-3. [DOI: 10.4103/jgid.jgid_316_20]

40. Konstantinus I, Chiwara D, Ndevaetela E, Ndarukwa-Phiri V, Garus-oas N, Frans N, et al. Laboratory and field evaluation of the STANDARD Q and Panbio™ SARS-CoV-2 antigen rapid test in Namibia using nasopharyngeal samples. *PloS One* 2022;**17**(9):e0269329. [DOI: 10.1371/journal.pone.0269329]

41. Konstantinus IS, Chiwara D, Ndevaetela EE, Ndarukwa-Phiri V, Garus-oas N, Frans N, et al. Laboratory and field evaluation of the STANDARD Q and PanbioTM SARS-CoV-2 antigen rapid test in Namibia using nasopharyngeal samples. MedRxiv (Preprint) 202110.1101/2021.09.21.21263886.

42. Labhardt ND, Gonzalez Fernandez, Katende B, Muhairwe J, Bresser M, Amstutz A, et al. Head-to-head comparison of nasal and nasopharyngeal sampling using SARS-CoV-2 rapid antigen testing in Lesotho. MedRxiv [Preprint] 20222021.12.29.21268505. [DOI: 10.1101/2021.12.29.21268505]

43. Landaas ET, Storm ML, Tollånes MC, Barlinn R, Kran AB, Bragstad K, et al. Diagnostic performance of a SARS-CoV-2 rapid

antigen test in a large, Norwegian cohort. *Journal of Clinical Virology* 2021;**137**:104789.

44. Leber W, Lammel O, Siebenhofer A, Redlberger-Fritz M, Panovska-Griffiths J, Czypionka T. Comparing the diagnostic accuracy of point-of-care lateral flow antigen testing for SARS-CoV-2 with RT-PCR in primary care (REAP-2). *EClinicalMedicine* 2021;**38**:101011. [DOI: 10.1016/j.eclinm.2021.101011]

45. Leiner J, Pellissier V, Nitsche A, König S, Hohenstein S, Nachtigall I, et al. SARS-CoV-2 rapid antigen testing in the healthcare sector: A clinical prediction model for identifying false negative results. *International Journal of Infectious Diseases* 2021;**112**:117-23. [DOI: 10.1016/j.ijid.2021.09.008]

46. Lopera TJ, Alzate-Ángel JC, Díaz FJ, Rugeles MT, Aguilar-Jimenez W. The usefulness of antigen testing in predicting contagiousness in COVID-19. *Microbiology Spectrum* 2022;**10**(2):e01962-21.

47. Majam M, Msolomba V, Venter F, Scott LE, Kahamba T, Stevens WS, et al. Monitored implementation of COVID-19 rapid antigen screening at taxi ranks in Johannesburg, South Africa. *Diagnostics* 2022;**12**(2):402. [DOI: 10.3390/diagnostics12020402]

48. Paul D, Gupta A, Rooge S, Gupta E. Performance evaluation of automated chemiluminescence immunoassay based antigen detection - Moving towards more reliable ways to predict SARS-CoV-2 infection [Performance evaluation of automated chemiluminescence immunoassay based antigen detection - Moving towards more reliable ways to predict SARS-CoV-2 infection]. *Journal of Virological Methods* 2021;**298**:114299. [DOI: 10.1016/j.jviromet.2021.114299]

49. Randriamahazo TR, Andrianarivelo AM, Rakotoarivo AT, Raheritiana TM, Rakotovao LA, Randriamanantany ZA, et al; ARasamindrakotroka. Evaluation of antigen-based rapid detection test for the diagnosis of SARS CoV-2 in low-income countries [Evaluation of antigen-based rapid detection test for the diagnosis of SARS CoV-2 in low-income countries]. *Journal of Virological Methods* 2021;**12**(5):114409. [DOI: 10.1016/j.jviromet.2021.114409]

50. Robinson ML, Mirza A, Gallagher N, Boudreau A, Garcia Jacinto L, Yu T, et al; KKafka. Limitations of molecular and antigen test performance for SARS-cov-2 in symptomatic and asymptomatic COVID-19 contacts [Limitations of Molecular and Antigen Test Performance for SARS-CoV-2 in Symptomatic and Asymptomatic COVID-19 Contacts]. *Journal of Clinical Microbiology* 2022;**60**(7):e00187-22. [DOI: 10.1128/jcm.00187-22]

51. Singh A, Gupta P, Mathuria YP, Kalita D, Prasad A, Panda PK, et al. Comparative evaluation of nasopharyngeal and oropharyngeal swab based rapid SARS-cov-2 antigen detection and real-time RT-PCR for diagnosis of COVID-19 in tertiary care hospital. Cureus 2021;**13**(7):e16785.

52. Tande AJ, Binnicker MJ, Ting HH, Del Rio C, Jalil L, Brawner M, et al. SARS-cov-2 testing before international airline travel, December 2020 to May 2021 [SARS-CoV-2 Testing Before International Airline Travel, December 2020 to May 2021]. *Mayo Clinic Proceedings* 2021;**96**(11):2856-60. [DOI: 10.1016/j.mayocp.2021.08.019]

53. Treggiari D, Piubelli C, Caldrer S, Mistretta M, Ragusa A, Orza P, et al. SARS-CoV-2 rapid antigen test in comparison to RT-PCR targeting different genes: a real-life evaluation among unselected patients in a regional hospital of Italy. *Journal of Medical Virology* 2022;**94**:1190-5. [DOI: 10.1002/jmv.27378]

54. Wagenhäuser I, Knies K, Rauschenberger V, Eisenmann M, McDonogh M, Petri N, et al. Clinical performance evaluation of SARS-CoV-2 rapid antigen testing in point of care usage in comparison to RT-qPCR. *EBioMedicine* 2021;**69**:103455.

55. Whiting PF, Rutjes AW, Westwood ME, Mallett S, Deeks JJ, Reitsma JB, et al. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. *Annals of Internal Medicine* 2011;**155**(8):529-36.

56. Chu H, Cole SR. Bivariate meta-analysis of sensitivity and specificity with sparse data: a generalized linear mixed model approach. *Journal of Clinical Epidemiology* 2006;**59**(12):1331-2.

57. Reitsma JB, Glas AS, Rutjes AW, Scholten RJ, Bossuyt PM, Zwinderman AH. Bivariate analysis of sensitivity and specificity produces informative summary measures in diagnostic reviews. *Journal of Clinical Epidemiology* 2005;**58**(10):982-90. [DOI: 10.1016/j.jclinepi.2005.02.022]

58. Stata. Version 18. College Station, TX, USA: StataCorp, 2023. Available at www.stata.com.

59. Takwoingi Y, Guo B, Riley RD, Deeks JJ. Performance of methods for meta-analysis of diagnostic test accuracy with few studies or sparse data. *Statistical Methods in Medical Research* 2017;**26**(4):1896-911.

60. Clopper CJ, Pearson ES. The use of confidence or fiducial limits Illustrated in the case of the binomial. *Biometrika* 1934;**26**:404-13.

61. Leeflang MM, Steingart KR, Scholten RJ, Davenport C. Drawing conclusions. In: Deeks JJ, Bossuyt PM, Leeflang MM, Takwoingi Y, editor(s). Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. 1st edition. Chichester (UK): John Wiley & Sons, 2023.

62. McInnes MD, Moher D, Thombs BD, McGrath TA, Bossuyt PM; PRISMA-DTA Group. Preferred reporting items for a systematic review and meta-analysis of diagnostic test accuracy studies: the PRISMA-DTA Statement. *JAMA* 2018;**319**(4):388-96. [DOI: 10.1001/jama.2017.19163] [PMID: 29362800]

63. Foundation for Innovative New Diagnostics (FIND). Evaluation of Abbott Panbio COVID-19 Ag Rapid Test Device - External Report. Switzerland: FIND, 2020.

64. Krüger LJ, Gaeddert M, Tobian F, Lainati F, Klein JA, Schnitzler P, et al. Evaluation of the accuracy and ease-of-use of Abbott PanBio - a WHO emergency use listed, rapid, antigen-detecting point-of-care diagnostic test for SARS-CoV-2. MedRxiv [Preprint] 202010.1101/2020.11.27.20239699v2.

65. Krüger LJ, Gaeddert M, Tobian F, Lainati F, Gottschalk C, Klein JAF, et al. The Abbott PanBio WHO emergency use listed, rapid, antigen-detecting point-of-care diagnostic test for SARS-

CoV-2 - Evaluation of the accuracy and ease-of-use. *PloS One* 2021;**16**(5):e0247918.

66. Boum Y, Fai KN, Nikolay B, Mboringong AB, Bebell LM, Ndifon M, et al. Performance and operational feasibility of antigen and antibody rapid diagnostic tests for COVID-19 in symptomatic and asymptomatic patients in Cameroon: a clinical, prospective, diagnostic accuracy study. *Lancet Infectious Diseases* 2021;**21**(8):1089-96.

67. Prince-Guerra JL, Almendares O, Nolen LD, Gunn JK, Dale AP, Buono SA, et al. Evaluation of Abbott Binaxnow rapid antigen test for SARS-Cov-2 infection at two community-based testing sites – Pima county, Arizona, November 3-17, 2020. *MMWR: Morbidity and Mortality Weekly Report* 2021;**70**(3):100-5.

68. Pilarowski G, Marquez C, Rubio L, Peng J, Martinez J, Black D, et al. Field performance and public health response using the BinaxNOW TM Rapid SARS-CoV-2 antigen detection assay during community-based testing. *Clinical Infectious Diseases* 2020;**73**(9):e3098–101. [DOI: 10.1093/cid/ciaa1890]

69. Pray IW, Ford L, Cole D, Lee C, Bigouette JP, Abedi GR, et al. Performance of an antigen-based test for asymptomatic and symptomatic SARS-CoV-2 testing at two university campuses - Wisconsin, September-October 2020. *MMWR: Morbidity and Mortality Weekly Report* 2021;**69**(5152):1642-7.

70. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. Five antigen tests for SARS-CoV-2: virus viability matters. *Viruses* 2021;**13**(4):684. [DOI: 10.3390/v13040684]

71. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. Five antigen tests for SARS-CoV-2: virus viability matters. *Viruses* 2021;**13**(4):684. [DOI: 10.3390/v13040684]

72. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. Five antigen tests for SARS-CoV-2: virus viability matters. *Viruses* 2021;**13**(4):684. [DOI: 10.3390/v13040684]

73. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. Five antigen tests for SARS-CoV-2: virus viability matters. *Viruses* 2021;**13**(4):684. [DOI: 10.3390/v13040684]

74. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. Five antigen tests for SARS-CoV-2: virus viability matters. *Viruses* 2021;**13**(4):684. [DOI: 10.3390/v13040684]

75. Baro B, Rodo P, Ouchi D, Bordoy AE, Saya Amaro EN, Salsench SV, et al. Performance characteristics of five antigen-detecting rapid diagnostic test (Ag-RDT) for SARS-CoV-2 asymptomatic infection: a head-to-head benchmark comparison. *Journal of Infection* 2021;**82**(6):269-75.

76. Baro B, Rodo P, Ouchi D, Bordoy AE, Saya Amaro EN, Salsench SV, et al. Performance characteristics of five antigen-detecting rapid diagnostic test (Ag-RDT) for SARS-CoV-2 asymptomatic infection: a head-to-head benchmark comparison. *Journal of Infection* 2021;**82**(6):269-75.

77. Baro B, Rodo P, Ouchi D, Bordoy AE, Saya Amaro EN, Salsench SV, et al. Performance characteristics of five antigen-detecting rapid diagnostic test (Ag-RDT) for SARS-CoV-2 asymptomatic infection: a head-to-head benchmark comparison. *Journal of Infection* 2021;**82**(6):269-75.

78. Baro B, Rodo P, Ouchi D, Bordoy AE, Saya Amaro EN, Salsench SV, et al. Performance characteristics of five antigen-detecting rapid diagnostic test (Ag-RDT) for SARS-CoV-2 asymptomatic infection: a head-to-head benchmark comparison. *Journal of Infection* 2021;**82**(6):269-75.

79. Baro B, Rodo P, Ouchi D, Bordoy AE, Saya Amaro EN, Salsench SV, et al. Performance characteristics of five antigen-detecting rapid diagnostic test (Ag-RDT) for SARS-CoV-2 asymptomatic infection: a head-to-head benchmark comparison. *Journal of Infection* 2021;**82**(6):269-75.

80. Abdul-Mumin A, Abubakari A, Agbozo F, Abdul-Karim A, Nuertey BD, Mumuni K, et al. Field evaluation of specificity and sensitivity of a standard SARS-CoV-2 antigen rapid diagnostic test: a prospective study at a teaching hospital in Northern Ghana. *PLOS Global Public Health* 2021;**1**(12):e0000040. [DOI: 10.1371/journal.pgph.0000040]

81. Abdul-Mumin A, Abubakari A, Agbozo F, Abdul-Karim A, Demah N, Mumuni K, et al. Field evaluation of specificity and sensitivity of a standard SARS-CoV-2 antigen rapid diagnostic test: a prospective study at a teaching hospital in Northern Ghana. MedRxiv [Preprint] 20212021.06.03.21258300. [DOI: 10.1101/2021.06.03.21258300]

82. Agulló V, Fernández-González M, Ortiz de la Tabla V, Gonzalo-Jiménez N, García JA, Masiá M, et al. Evaluation of the rapid antigen test Panbio COVID-19 in saliva and nasal swabs in a population-based point-of-care study. *Journal of Infection* 2021;**82**(5):186-230.

83. Billaud G, Gaymard A, Lina B; Laboratoire de Virologie des HCL CNR des virus des infections respiratoires. Evaluation du Test Antigénique ABBOTT SARS-COV2 ABBOT. Lyon, France: SFM (French Society of Microbiology), 2020.

84. Bulilete O, Lorente P, Leiva A, Carandell E, Oliver A, Rojo E, et al. Panbio rapid antigen test for SARS-CoV-2 has acceptable accuracy in symptomatic patients in primary health care. *Journal of Infection* 2021;**82**(3):391-8.

85. Bulilete O, Lorente P, Leiva A, Carandell E, Oliver A, Rojo E, et al. Evaluation of the Panbio rapid antigen test for SARS-CoV-2 in primary health care centers and test sites. MedRxiv [Preprint] 20202020.11.13.20231316. [DOI: 10.1101/2020.11.13.20231316]

86. Del Vecchio C, Brancaccio G, Brazzale AR, Lavezzo E, Onelia F, Franchin E, et al. Emergence of N antigen SARS-CoV-2 genetic variants escaping detection of antigenic tests. MedRxiv [Preprint] 20212021.03.25.21253802. [DOI: 10.1101/2021.03.25.21253802]

87. Drain P, Sulaiman R, Hoppers M, Lindner NM, Lawson V, Ellis JE. Performance of the lumiradx microfluidic immunofluorescence point-of-care SARS-cov-2 antigen test in asymptomatic adults and children. American Journal of Clinical Pathology 2021;**157**(4):602-7.

88. Drevinek P, Hurych J, Kepka Z, Briksi A, Kulich M, Zajac M, et al. The sensitivity of SARS-CoV-2 antigen tests in the view of large-scale testing. MedRxiv [Preprint] 20202020.11.23.20237198. [DOI: 10.1101/2020.11.23.20237198]

89. Farfour E, Amiel C, Jolly E, Zia-Chahabi S, Mazaux L, Simonin P, et al. The panbio COVID-19 ag rapid test: which performances are for COVID-19 diagnosis? *Clinical Laboratory* 2021;**67**(11):Clin.Lab.2021.210304.

90. Fenollar F, Bouam A, Ballouche M, Fuster L, Prudent E, Colson P, et al. Evaluation of the Panbio Covid-19 rapid antigen detection test device for the screening of patients with COVID-19. *Journal of Clinical Microbiology* 2020;**59**:10.1128/jcm.02589-20. [DOI: 10.1128/JCM.02589-20]

91. Fernandez MD, Estevez AS, Alfonsin FL, Arevalo GB. Usefulness of the Lumiradx SARS-CoV-2 antigen test in nursing homes [Utilidad del test de antígenos SARS-COV-2 de LumiraDx™ en centros residenciales]. *Enfermedades Infecciosas y Microbiología Clínica (English Edition)* 2022;**40**(7):404-5. [DOI: 10.1016/j.eimc.2021.06.006]

92. Garcia-Cardenas F, Peñaloza F, Bertin-Montoya J, Valdéz-Vázquez R, Franco A, Cortés R, et al. Analytical performances of the COVISTIXTM antigen rapid test for SARS-cov-2 detection in an unselected population (all-comers). *Pathogens* 2022;**11**(6):628.

93. Garcia-Cardenas F, Franco A, Cortes R, Bertin J, Valdez R, Penaloza F, et al. Analytical performances of the COVISTIX and Panbio antigen rapid tests for SARS-CoV-2 detection in an unselected population (all commers). MedRxiv (Preprint) 202110.1101/2021.09.10.21263410.

94. Gremmels H, Winkel BM, Schuurman R, Rosingh A, Rigter NA, Rodriguez O, et al. Real-life validation of the PanbioTM COVID-19 antigen rapid test (Abbott) in community-dwelling subjects with symptoms of potential SARS-CoV-2 infection. *EClinicalMedicine* 2021;**31**:100677. [DOI: 10.1016/j.eclinm.2020.100677]

95. Gremmels H, Winkel BM, Schuurman R, Rosingh A, Rigter NA, Rodriguez O, et al. Real-life validation of the Panbio COVID-19 Antigen Rapid Test (Abbott) in community-dwelling subjects with symptoms of potential SARS-CoV-2 infection. MedRxiv [Preprint] 202010.1101/2020.10.16.20214189. [DOI: 10.1101/2020.10.16.20214189]

96. Gupta A, Khurana S, Das R, Srigyan D, Singh A, Mittal A, et al. Rapid chromatographic immunoassay-based evaluation of COVID-19: a cross-sectional, diagnostic test accuracy study & its implications for COVID-19 management in India. *Indian Journal of Medical Research* 2021;**153**(1-2):126-31. [DOI: 10.4103/ijmr.IJMR_3305_20]

97. Homza M, Zelena H, Janosek J, Tomaskova H, Jezo E, Kloudova A, et al. COVID-19 antigen testing: better than we know? A test accuracy study. *Infectious Diseases (London)* 2021;**53**(9):661-8.

98. Kanaujia R, Ghosh A, Mohindra R, Singla V, Goyal K, Gudisa R, et al. Rapid antigen detection kit for the diagnosis of SARS-CoV-2 - are we missing asymptomatic patients? Indian Journal of Medical Microbiology 2021;**39**(4):457-61.

99. Klein JA, Kruger LJ, Tobian F, Gaeddert M, Lainati F, Schnitzler P, et al. Head-to-head performance comparison of self-collected nasal versus professional-collected nasopharyngeal swab for a WHO-listed SARS-CoV-2 antigen-detecting rapid diagnostic test. *Medical Microbiology and Immunology* 2021;**210**(4):181-6.

100. Krüger LJ, Klein JA, Tobian F, Gaeddert M, Lainati F, Klemm S, et al. Evaluation of accuracy, exclusivity, limit-of-detection and ease-of-use of LumiraDx™: an antigen-detecting point-of-care device for SARS-CoV-2. *Infection* 2022;**50**(2):395-406. [DOI: 10.1007/s15010-021-01681-y]

101. Krüger LJ, Klein JA, Tobian F, Gaeddert M, Lainati F, Klemm S, et al. Evaluation of accuracy, exclusivity, limit-of-detection and ease-of-use of LumiraDx-Antigen-detecting point-of-care device for SARS-CoV-2. MedRxiv [Preprint] 20212021.03.02.21252430. [DOI: 10.1101/2021.03.02.21252430]

102. L'Huillier AG, Lacour M, Sadiku D, Gadiri MA, De Siebenthal L, Schibler M, et al. Diagnostic accuracy of SARS-CoV-2 rapid antigen detection testing in symptomatic and asymptomatic children in the clinical setting. *Journal of Clinical Microbiology* 2021;**59**(9):e0099121. [1098-660X: (Electronic)]

103. Masiá M, Fernández-González M, Sánchez M, Carvajal M, García JA, Gonzalo-Jiménez N, et al. Nasopharyngeal Panbio COVID-19 antigen performed at point-of-care has a high sensitivity in symptomatic and asymptomatic patients with higher risk for transmission and older age. *Open Forum Infectious Diseases* 2021;**8**(3):ofab059. [DOI: 10.1093/ofid/ofab059]

104. Masia M, Fernandez-Gonzalez M, Sanchez M, Carvajal M, Garcia JA, Gonzalo N, et al. Nasopharyngeal Panbio COVID-19 antigen performed at point-of-care has a high sensitivity in symptomatic and asymptomatic patients with higher risk for transmission and older age. MedRxiv [Preprint] 20202020.11.16.20230003. [DOI: 10.1101/2020.11.16.20230003]

105. Merino P, Guinea J, Muñoz-Gallego I, González-Donapetry P, Galán JC, Antona N, et al. Multicenter evaluation of the Panbio™ COVID-19 rapid antigen-detection test for the diagnosis of SARS-CoV-2 infection. *Clinical Microbiology and Infection* 2021;**27**(5):758-61. [DOI: 10.1016/j.cmi.2021.02.001]

106. Merino-Amador P, Guinea J, Muñoz-Gallego I, González-Donapetry P, Galán J-C, Antona N, et al. Multicenter evaluation of the Panbio™ COVID-19 Rapid Antigen-Detection Test for the diagnosis of SARS-CoV-2 infection. MedRxiv [Preprint] 202010.1101/2020.11.18.20230375. [DOI: 10.1101/c]

107. Merino-Amador P, Gonzalez-Donapetry P, Dominguez-Fernandez M, Gonzalez-Romo F, Sanchez-Castellano MA, Seoane-Estevez A, et al. Clinitest rapid COVID-19 antigen test for the diagnosis of SARS-CoV-2 infection: a multicenter evaluation study. *Journal of Clinical Virology* 2021;**143**:104961.

108. Nagura-Ikeda M, Imai K, Tabata S, Miyoshi K, Murahara N, Mizuno T, et al. Clinical evaluation of self-collected saliva by quantitative reverse transcription-PCR (RT-qPCR), direct

RT-qPCR, reverse transcription-loop-mediated isothermal amplification, and a rapid antigen test to diagnose COVID-19. *Journal of Clinical Microbiology* 2020;**58**(9):e01438-20. [DOI: 10.1128/JCM.01438-20]

109. Schuit E, Veldhuijzen I, Venekamp R, Van den Bijllaardt W, Pas S, Lodder E, et al. Diagnostic accuracy of rapid antigen tests in asymptomatic and presymptomatic close contacts of individuals with confirmed SARS-CoV-2 infection: cross-sectional study. *BMJ (Clinical Research Ed.)* 2021;**374**:n1676. [DOI: 10.1136/bmj.n1676]

110. Schuit E, Veldhuijzen I, Venekamp R, Van den Bijllaardt W, Pas S, Lodder E, et al. Diagnostic accuracy of rapid antigen tests in pre-/asymptomatic close contacts of individuals with a confirmed SARS-CoV-2 infection. MedRxiv [Preprint] 20212021.03.18.21253874. [DOI: 10.1101/2021.03.18.21253874]

111. Schuit E, Veldhuijzen I, Venekamp R, Van den Bijllaardt W, Pas S, Lodder E, et al. Diagnostic accuracy of rapid antigen tests in asymptomatic and presymptomatic close contacts of individuals with confirmed SARS-CoV-2 infection: cross-sectional study. *BMJ (Clinical Research Ed.)* 2021;**374**:n1676. [DOI: 10.1136/bmj.n1676]

112. Schuit E, Veldhuijzen I, Venekamp R, Van den Bijllaardt W, Pas S, Lodder E, et al. Diagnostic accuracy of rapid antigen tests in pre-/asymptomatic close contacts of individuals with a confirmed SARS-CoV-2 infection. MedRxiv [Preprint] 20212021.03.18.21253874. [DOI: 10.1101/2021.03.18.21253874]

113. Shrestha B, Neupane AK, Pant S, Shrestha A, Bastola A. Sensitivity and specificity of lateral flow antigen test kits for COVID-19 in asymptomatic population of quarantine centre of Province 3. *Kathmandu University Medical Journal (KUMJ)* 2020;**18**(70):36-9.

114. Takeuchi Y, Akashi Y, Kato D, Kuwahara M, Muramatsu S, Ueda A, et al. The evaluation of a newly developed antigen test (QuickNavi™-COVID19 Ag) for SARS-CoV-2: a prospective observational study in Japan. *Journal of Infection and Chemotherapy* 2021;**27**(6):890-4. [DOI: 10.1016/j.jiac.2021.02.029]

115. Takeuchi Y, Akashi Y, Kato D, Kuwahara M, Muramatsu S, Ueda A, et al. The evaluation of a newly developed antigen test (QuickNaviTM-COVID19 Ag) for SARS-CoV-2: a prospective observational study in Japan. MedRxiv [Preprint] 20212020.12.27.20248876. [DOI: 10.1101/2020.12.27.20248876]

116. Takeuchi Y, Akashi Y, Kiyasu Y, Terada N, Kurihara Y, Kato D, et al. A prospective evaluation of diagnostic performance of a combo rapid antigen test QuickNavi-Flu+COVID19 Ag. *Journal of Infection and Chemotherapy* 2022;**28**(6):840-3. [DOI: 10.1016/j.jiac.2022.02.027]

117. Takeuchi Y, Akashi Y, Kiyasu Y, Terada N, Kurihara Y, Kato D, et al. Clinical evaluation of a combo rapid antigen test QuickNavi-Flu+COVID19 Ag for simultaneous detection of SARS-CoV-2 and influenza viruses. MedRxiv [Preprint] 202110.1101/2021.12.05.21267215. [DOI: 10.1101/2021.12.05.21267215]

118. Thirion-Romero I, Guerrero-Zúñiga Dr S, Arias-Mendoza Dr A, Cornejo-Juárez Dr DP, Meza-Meneses Dr P, Torres-Erazo Dr DS, et al. Evaluation of Panbio rapid antigen test for SARS-CoV-2 in symptomatic patients and their contacts: a multicenter study. *International Journal of Infectious Diseases* 2021;**113**:218-24. [DOI: 10.1016/j.ijid.2021.10.027]

119. Thirion-Romero I, Guerrero-Zuniga S, Arias-Mendoza A, Cornejo-Juarez DP, Meza-Meneses P, Torres-Erazo DS, et al. Evaluation of a rapid antigen test for SARS-CoV-2 in symptomatic patients and their contacts: a multicenter study. MedRxiv [Preprint] 202110.1101/2021.05.24.21257020.

120. Torres I, Poujois S, Albert E, Colomina J, Navarro D. Evaluation of a rapid antigen test (Panbio COVID-19 Ag rapid test device) for SARS-CoV-2 detection in asymptomatic close contacts of COVID-19 patients. *Clinical Microbiology and Infection* 2021;**27**(4):636 e1-4.

121. Torres I, Poujois S, Albert E, Colomina J, Navarro D. Real-life evaluation of a rapid antigen test (Panbio COVID-19 Ag Rapid Test Device) for SARS-CoV-2 detection in asymptomatic close contacts of COVID-19 patients. MedRxiv [Preprint] 20202020.12.01.20241562. [DOI: 10.1101/2020.12.01.20241562]

122. Torres I, Poujois S, Albert E, Alvarez G, Colomina J, Navarro D. Point-of-care evaluation of a rapid antigen test (CLINITEST® Rapid COVID-19 Antigen Test) for diagnosis of SARS-CoV-2 infection in symptomatic and asymptomatic individuals. *Journal of Infection* 2021;**82**(5):e11-2.

123. Torres I, Poujois S, Albert E, Álvarez G, Colomina J, Navarro D. Point-of-care evaluation of a rapid antigen test (CLINITEST® Rapid COVID-19 Antigen Test) for diagnosis of SARS-CoV-2 infection in symptomatic and asymptomatic individuals. MedRxiv [Preprint] 2021021.02.02.21250984. [DOI: 10.1101/2021.02.02.21250984]

124. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for severe acute respiratory syndrome Coronavirus 2 in close contacts of individuals with confirmed infection: performance and operational considerations. *Journal of Infectious Diseases* 2022;**226**(12):2118-28. [DOI: 10.1093/infdis/jiac204]

125. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for SARS-CoV-2 in close contacts of individuals with confirmed infection: performance and operational considerations. MedRxiv [Preprint] 202210.1101/2022.01.27.22269904.

126. Agarwal J, Das A, Pandey P, Sen M, Garg J. 'David vs. Goliath': a simple antigen detection test with potential to change diagnostic strategy for SARS-CoV-2. Journal of Infection in Developing Countries 2021;**15**(7):904-9. [DOI: 10.3855/jidc.13925]

127. Alghounaim M, Bastaki H, Bin Essa F, Motlagh H, Al-Sabah S. The performance of two rapid antigen tests during population-level screening for SARS-CoV-2 infection. *Frontiers in Medicine* 2021;**8**:797109. [DOI: 10.3389/fmed.2021.797109]

128. Bonde J, Ejegod DM, Pedersen H, Smith B, Cortes D, Leding C, et al. Clinical validation of point-of-care SARS-

COV-2 BD Veritor antigen test by a single throat swab for rapid COVID-19 status on hospital patients predominantly without overt COVID symptoms. MedRxiv [Preprint] 20212021.04.12.21255299. [DOI: 10.1101/2021.04.12.21255299]

129. Escriva BF, Mochon MD, Gonzalez RM, Garcia CS, Pla AT, Ricart AS, et al. The effectiveness of rapid antigen test-based for SARS-CoV-2 detection in nursing homes in Valencia, Spain. *Journal of Clinical Virology* 2021;**143**:10.1016/j.jcv.2021.104941.

130. Nalumansi A, Lutalo T, Kayiwa J, Watera C, Balinandi S, Kiconco J, et al. Field evaluation of the performance of a SARS-CoV-2 antigen rapid diagnostic test in Uganda using nasopharyngeal samples. *International Journal of Infectious Diseases* 2021;**104**:282-6. [DOI: 10.1016/j.ijid.2020.10.073]

131. Brihn A, Chang J, OYong K, Balter S, Terashita D, Rubin Z, et al. Diagnostic performance of an antigen test with RT-PCR for the detection of SARS-CoV-2 in a hospital setting - Los Angeles County, California, June-August 2020. *MMWR Morbidity & Mortality Weekly Report* 2021;**70**(19):702-6.

132. Halfon P, Penaranda G, Khiri H, Garcia V, Drouet H, Philibert P, et al. An optimized stepwise algorithm combining rapid antigen and RT-qPCR for screening of COVID-19 patients. *PloS One* 2021;**16**(9):e0257817. [DOI: 10.1371/journal.pone.0257817]

133. Halfon P, Penaranda G, Khiri H, Garcia V, Drouet H, Philibert P, et al. An optimized stepwise algorithm combining rapid antigen and RT-qPCR for screening of COVID-19 patients. MedRxiv[Preprint] 20212021.01.13.21249254. [DOI: 10.1101/2021.01.13.21249254v1]

134. Jakobsen KK, Schmidt J, Todsen T, Kirkby N, Lippert F, Vangsted AM, et al. Accuracy of anterior nasal swab rapid antigen tests compared with RT-PCR for massive SARS-CoV-2 screening in low prevalence population. APMIS: Acta Pathologica, Microbiologica, et Immunologica Scandinavica 2022;**130**(2):95-100.

135. Linares M, Pérez-Tanoira R, Carrero A, Romanyk J, Pérez-García F, Gómez-Herruz P, et al. Panbio antigen rapid test is reliable to diagnose SARS-CoV-2 infection in the first 7 days after the onset of symptoms. *Journal of Clinical Virology* 2020;**133**:104659. [DOI: 10.1016/j.jcv.2020.104659]

136. Linares M, Pérez TR, Romanyk J, Pérez García F, Gómez-Herruz P, Arroyo T, et al. Panbio antigen rapid test is reliable to diagnose SARS-CoV-2 infection in the first 7 days after the onset of symptoms. MedRxiv [Preprint] 202010.1101/2020.09.20.20198192. [DOI: 10.1101/2020.09.20.20198192]

137. Parada-Ricart E, Gomez-Bertomeu F, Pico-Plana E, Olona-Cabases M. Usefulness of the antigen for diagnosing SARS-CoV-2 infection in patients with and without symptoms [Utilidad del antígeno para el diagnóstico de infección por SARS-CoV-2 en pacientes con y sin síntomas]. *Enfermedades Infecciosas y Microbiología Clínica (English Edition)* 2021;**39**(7):357-8. [DOI: 10.1016/j.eimc.2020.09.009]

138. Schildgen V, Demuth S, Lüsebrink J, Schildgen O. Limits and opportunities of SARS-CoV-2 antigen rapid tests: an experienced-based perspective. *Pathogens* 2021;**10**(1):38. [DOI: 10.3390/pathogens10010038]

139. Schildgen V, Demuth S, Lüsebrink J, Schildgen O. Limits and opportunities of SARS-CoV-2 antigen rapid tests - an experience based perspective. MedRxiv [Preprint] 20202020.09.22.20199372. [DOI: 10.1101/2020.09.22.20199372]

140. Scohy A, Anantharajah A, Bodeus M, Kabamba-Mukadi B, Verroken A, Rodriguez-Villalobos H. Low performance of rapid antigen detection test as frontline testing for COVID-19 diagnosis. *Journal of Clinical Virology* 2020;**129**:104455. [DOI: 10.1016/j.jcv.2020.104455]

141. Shah MM, Salvatore PP, Ford L, Kamitani E, Whaley MJ, Mitchell K, et al. Performance of repeat BinaxNOW severe acute respiratory syndrome coronavirus 2 antigen testing in a community setting, Wisconsin, November 2020-December 2020. *Clinical Infectious Diseases* 2021;**73 Suppl 1**:S54-7.

142. Boyle AA, Hardwick S, Warne B, Nwuba CK, Brown N, Shaw A. Evaluating the sensitivity and specificity of Siemens Clinitest lateral flow test and the simple amplification-based assay (SAMBA)-2 PCR test for SARS-CoV-2 infection. Cureus 2021;**13**(9):e18319.

143. Holzner C, Pabst D, Anastasiou OE, Dittmer U, Manegold RK, Risse J, et al. SARS-CoV-2 rapid antigen test: fast-safe or dangerous? An analysis in the emergency department of an university hospital. *Journal of Medical Virology* 2021;**93**(9):5323-7.

144. Leli C, Matteo LD, Gotta F, Cornaglia E, Vay D, Megna I, et al. Performance of a SARS CoV-2 antigen rapid immunoassay in patients admitted to the Emergency Department. International Journal of Infectious Diseases 2021;**110**:135-40.

145. Menchinelli G, De Angelis G, Cacaci M, Liotti FM, Candelli M, Palucci I, et al. Sars-Cov-2 antigen detection to expand testing capacity for Covid-19: results from a hospital emergency department testing site. *Diagnostics* 2021;**11**(7):1211.

146. Quentin O, Sylvie P, Olivier M, Julie G, Charlotte T, Nadine A, et al. Prospective evaluation of the point-of-care use of a rapid antigenic SARS-CoV-2 immunochromatographic test in a pediatric emergency department. *Clinical Microbiology and Infection* 2022;**28**(5):734.e1-734.e6.

147. Reichert F, Enninger A, Plecko T, Zoller WG, Paul G. Pooled SARS-CoV-2 antigen tests in asymptomatic children and their caregivers: screening for SARS-CoV-2 in a pediatric emergency department. *American Journal of Infection Control* 2021;**49**(10):1242-6.

148. Smith RD, Johnson JK, Clay C, Girio-Herrera L, Stevens D, Abraham M, et al. Clinical evaluation of Sofia rapid antigen assay for detection of severe acute respiratory syndrome coronavirus 2 among emergency department to hospital admissions. *Infection Control and Hospital Epidemiology* 2021;**43**(8):968-73. [DOI: 10.1017/ice.2021.281]

149. Turcato G, Zaboli A, Pfeifer N, Sibilio S, Tezza G, Bonora A, et al. Rapid antigen test to identify COVID-19 infected patients

with and without symptoms admitted to the Emergency Department. *American Journal of Emergency Medicine* 2021;**51**:92-7.

150. Turcato G, Zaboli A, Pfeifer N, Ciccariello L, Sibilio S, Tezza G, et al. Clinical application of a rapid antigen test for the detection of SARS-CoV-2 infection in symptomatic and asymptomatic patients evaluated in the emergency department: a preliminary report. *Journal of Infection* 2021;**82**(3):e14-6.

151. Aranaz-Andrés JM, Chávez AC, Laso AM, Abreu M, Núñez PM, Galán JC, et al. Analysis of the diagnostic accuracy of rapid antigenic tests for detection of SARS-CoV-2 in hospital outbreak situation. *European Journal of Clinical Microbiology & Infectious Diseases* 2022;**41**(2):305-12. [DOI: 10.1007/s10096-021-04346-8]

152. Caruana G, Croxatto A, Kampouri E, Kritikos A, Opota O, Foerster M, et al. Implementing SARS-CoV-2 rapid antigen testing in the emergency ward of a Swiss university hospital: the INCREASE study. *Microorganisms* 2021;**9**(4):798.

153. Caruana G, Lebrun LL, Aebischer O, Opota O, Urbano L, De Rham M, et al. The dark side of SARS-CoV-2 rapid antigen testing: screening asymptomatic patients. *New Microbes and New Infections* 2021;**42**:100899.

154. Eleftheriou I, Dasoula F, Dimopoulou D, Lebessi E, Serafi E, Spyridis N, et al. Real-life evaluation of a COVID-19 rapid antigen detection test in hospitalized children. *Journal of Medical Virology* 2021;**93**(10):6040-4.

155. Kumar KK, Sampritha UC, Maganty V, Prakash AA, Basumatary J, Adappa K, et al. Pre-operative SARS-CoV-2 rapid antigen test and reverse transcription polymerase chain reaction: a conundrum in surgical decision making. *Indian Journal of Ophthalmology* 2021;**69**(6):1560-2.

156. Rottenstreich A, Zarbiv G, Kabiri D, Porat S, Sompolinsky Y, Reubinoff B, et al. Rapid antigen detection testing for universal screening for severe acute respiratory syndrome coronavirus 2 in women admitted for delivery. *American Journal of Obstetrics and Gynecology* 2021;**224**(5):539-40.

157. Stokes W, Berenger BM, Singh T, Adeghe I, Schneider A, Portnoy D, et al. Acceptable performance of the Abbott ID NOW among symptomatic individuals with confirmed COVID-19. *Journal of Medical Microbiology* 2021;**70**(7):001372.

158. Thakur P, Saxena S, Manchanda V, Rana N, Goel R, Arora R. Utility of antigen-based rapid diagnostic test for detection of SARS-CoV-2 virus in routine hospital settings. *Laboratory Medicine* 2021;**52**(6):e154-8.

159. Zellmer S, Ebigbo A, Kahn M, Muzalyova A, Classen J, Grünherz V, et al. Evaluation of the ESGE recommendations for COVID-19 pre-endoscopy risk-stratification in a high-volume center in Germany. *Endoscopy International Open* 2021;**9**(10):E1556-60.

160. Kahn M, Schuierer L, Bartenschlager C, Zellmer S, Frey R, Freitag M, et al. Performance of antigen testing for diagnosis of COVID-19: a direct comparison of a lateral flow device to nucleic acid amplification based tests. BMC Infectious Diseases 2021;**21**(1):798.

161. FIND. FIND Evaluation of Premier Medical Corporation Pvt. Ltd Sure Status COVID-19 Antigen Card Test. External Report. Switzerland: FIND, 2021.

162. Korenkov M, Poopalasingam N, Madler M, Vanshylla K, Eggeling R, Wirtz M, et al. Reliable assessment of in vitro SARS-CoV-2 infectivity by a rapid antigen detection test. MedRxiv [Preprint] 20212021.03.30.21254624. [DOI: 10.1101/2021.03.30.21254624]

163. Roger S, Lefeuvre C, Pivert A, Ducancelle A, Savary D, Bouthry A, et al. What is the true place of the SARS-CoV-2 rapid point-of-care antigen test in the hospital setting? Lessons learned from real life. *Journal of Medical Virology* 2021;**94**(4):1723-7.

164. Blanchard AC, Desforges M, Labbe AC, Nguyen CT, Petit Y, Besner D, et al. Evaluation of real-life use of Point-Of-Care Rapid Antigen TEsting for SARS-CoV-2 in schools for outbreak control (EPOCRATES). MedRxiv [Preprint] 202110.1101/2021.10.13.21264960.

165. Ferguson J, Dunn S, Best A, Mirza J, Percival B, Mayhew M, et al. Validation testing to determine the sensitivity of lateral flow testing for asymptomatic SARS-CoV-2 detection in low prevalence settings: testing frequency and public health messaging is key. *PLoS Biology* 2021;**19**(4):e3001216. [DOI: 10.1371/journal.pbio.3001216]

166. Ferguson J, Dunn S, Best A, Mirza J, Percival B, Mayhew M, et al. Validation testing to determine the effectiveness of lateral flow testing for asymptomatic SARS-CoV-2 detection in low prevalence settings. MedRxiv [Preprint] 20202020.12.01.20237784. [DOI: 10.1101/2020.12.01.20237784]

167. Fernandez-Montero A, Argemi J, Rodríguez JA, Ariño AH, Moreno-Galarraga L. Validation of a rapid antigen test as a screening tool for SARS-CoV-2 infection in asymptomatic populations. Sensitivity, specificity and predictive values. *EClinicalMedicine* 2021;**37**:100954.

168. Ferte T, Ramel V, Cazanave C, Lafon ME, Bebear C, Malvy D, et al. Accuracy of COVID-19 rapid antigenic tests compared to RT-PCR in a student population: the StudyCov study. *Journal of Clinical Virology* 2021;**141**:104878. [DOI: 10.1016/j.jcv.2021.104878]

169. Ford L, Lee C, Pray IW, Cole D, Bigouette JP, Abedi GR, et al. Epidemiologic characteristics associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antigen-based test results, real-time reverse transcription polymerase chain reaction (rRT-PCR) cycle threshold values, subgenomic RNA, and viral culture results from university testing. *Clinical Infectious Disease* 2021;**73**(6):e1348-55.

170. Harris DT, Badowski M, Jernigan B, Sprissler R, Edwards T, Cohen R, et al. SARS-CoV-2 rapid antigen testing of symptomatic and asymptomatic individuals on the University of Arizona campus. *Biomedicines* 2021;**9**(5):539. [DOI: 10.3390/biomedicines9050539]

171. Iftner T, Iftner A, Pohle D, Martus P. Evaluation of the specificity and accuracy of SARS-CoV-2 rapid antigen self-tests compared to RT-PCR from 1015 asymptomatic volunteers. MedRxiv [Preprint] 202210.1101/2022.02.11.22270873.

172. Iftner T, Iftner A, Pohle D, Martus P. Evaluation of the specificity and accuracy of SARS-CoV-2 rapid antigen self-tests compared to RT-PCR from 1015 asymptomatic volunteers. MedRxiv [Preprint] 202210.1101/2022.02.11.22270873.

173. Iftner T, Iftner A, Pohle D, Martus P. Evaluation of the specificity and accuracy of SARS-CoV-2 rapid antigen self-tests compared to RT-PCR from 1015 asymptomatic volunteers. MedRxiv [Preprint] 202210.1101/2022.02.11.22270873.

174. Iftner T, Iftner A, Pohle D, Martus P. Evaluation of the specificity and accuracy of SARS-CoV-2 rapid antigen self-tests compared to RT-PCR from 1015 asymptomatic volunteers. MedRxiv [Preprint] 202210.1101/2022.02.11.22270873.

175. Kriemler S, Ulyte A, Ammann P, Peralta GP, Berger C, Puhan MA, et al. Surveillance of acute SARS-CoV-2 infections in school children and point-prevalence during a time of high community transmission in Switzerland. *Frontiers in Pediatrics* 2021;**9**:159.

176. Okoye NC, Barker AP, Curtis K, Orlandi RR, Snavely EA, Wright C, et al. Performance characteristics of BinaxNOW COVID-19 Antigen Card for screening asymptomatic individuals in a university setting. *Journal of Clinical Microbiology* 2021;**59**(4):e03282-20. [DOI: 10.1128/JCM.03282-20]

177. Tinker SC, Szablewski CM, Litvintseva AP, Drenzek C, Voccio GE, Hunter MA, et al. Point-of-care antigen test for SARS-Cov-2 in asymptomatic college students. *Emerging Infectious Diseases* 2021;**27**(10):2662-5.

178. James AE, Gulley T, Kothari A, Holder K, Garner K, Patil N. Performance of the BinaxNOW coronavirus disease 2019 (COVID-19) Antigen Card test relative to the severe acute respiratory coronavirus virus 2 (SARS-CoV-2) real-time reverse transcriptase polymerase chain reaction (rRT-PCR) assay among symptomatic and asymptomatic healthcare employees. *Infection Control and Hospital Epidemiology* 2022;**43**(1):99-101. [DOI: 10.1017/ice.2021.20]

179. Osmanodja B, Budde K, Zickler D, Naik MG, Hofmann J, Gertler M, et al. Accuracy of a novel SARS-CoV-2 antigen-detecting rapid diagnostic test from standardized self-collected anterior nasal swabs. *Journal of Clinical Medicine* 2021;**10**(10):2099. [DOI: 10.3390/jcm10102099]

180. Von Ahnen T, Von Ahnen M, Wirth U, Schardey HM, Herdtle S. Evaluation of a rapid-antigen test for COVID-19 in an asymptomatic collective: a prospective study. *Wiener Medizinische Wochenschrift* 2021;**172**(3-4):70-3.

181. Cerutti F, Burdino E, Milia MG, Allice T, Gregori G, Bruzzone B, et al. Urgent need of rapid tests for SARS CoV-2 antigen detection: evaluation of the SD-Biosensor antigen test for SARS-CoV-2. *Journal of Clinical Virology* 2020;**132**:104654.

182. Qahtani MA, Yang CW, Lazosky L, Li X, D'Cruz J, Romney MG, et al. SARS-CoV-2 rapid antigen testing for departing passengers at Vancouver International Airport. *Journal of Travel Medicine* 2021;**28**(7):taab085. [DOI: 10.1093/jtm/taab085]

183. Di Domenico M, De Rosa A, Di Gaudio F, Internicola P, Bettini C, Salzano N, et al. Diagnostic accuracy of a new antigen test for SARS-CoV-2 detection. *International Journal of Environmental Research and Public Health* 2021;**18**(12):6310. [DOI: 10.3390/ijerph18126310]

184. Revollo B, Blanco I, Soler P, Toro J, Izquierdo-Useros N, Puig J, et al. Same-day SARS-CoV-2 antigen test screening in an indoor mass-gathering live music event: a randomised controlled trial. *Lancet Infectious Diseases* 2021;**21**(10):1365-72.

185. Revollo B, Blanco I, Soler P, Toro J, Izquierdo-Useros N, Puig J, et al. Same-day SARS-CoV-2 antigen test screening in an indoor mass-gathering live music event: a randomised controlled trial. *Lancet Infectious Diseases* 2021;**21**(10):1365-72.

186. Chiu RY, Kojima N, Mosley GL, Cheng KK, Pereira DY, Brobeck M, et al. Evaluation of the INDICAID COVID-19 rapid antigen test in symptomatic populations and asymptomatic community testing. *Microbiology Spectrum* 2021;**9**(1):e0034221. [DOI: 10.1128/Spectrum.00342-21]

187. Chiu R, Kojima N, Mosley G, Cheng KK, Pereira D, Brobeck M, et al. Evaluation of the INDICAID COVID-19 Rapid Antigen Test in symptomatic populations and asymptomatic community testing. MedRxiv [Preprint] 202110.1101/2021.05.26.21257063. [DOI: 10.1101/2021.05.26.21257063]

188. Mungomklang A, Trichaisri N, Jirachewee J, Sukprasert J, Tulalamba W, Viprakasit V. Limited sensitivity of a rapid SARS-CoV-2 antigen detection assay for surveillance of asymptomatic individuals in Thailand. *American Journal of Tropical Medicine and Hygiene* 2021;**105**(6):1505-9.

189. Diez Flecha C, Rivero Rodriguez AM, Fernandez-Villa T, Fernandez Garcia P, Ferreira de Jesus JL, Sanchez Antolin G, et al. Internal validity of a rapid test for COVID-19 antigens in a nursing home. *Semergen* 2021;**47**(5):332-6.

190. Ifko M, Skvarc M. Use of immunochromatographic SARS-cov-2 antigen testing in eight long-term care facilities for the elderly. Healthcare (Basel, Switzerland) 2021;**9**(7):10.3390/healthcare9070868.

191. Alemany A, Baro B, Ouchi D, Rodó P, Ubals M, Corbacho-Monné M, et al. Analytical and clinical performance of the Panbio COVID-19 antigen-detecting rapid diagnostic test. *Journal of Infection* 2021;**82**(5):186-230. [DOI: 10.1016/j.jinf.2020.12.033]

192. Alemany A, Baro B, Ouchi D, Ubals M, Corbacho-Monné M, Vergara-Alert J, et al. Analytical and clinical performance of the Panbio COVID-19 antigen-detecting rapid diagnostic test. MedRxiv [Preprint] 20202020.10.30.20223198. [DOI: 10.1101/2020.10.30.20223198]

193. Cubas-Atienzar AI, Bell F, Byrne RL, Buist K, Clark DJ, Cocozza M, et al. Accuracy of the Mologic COVID-19 rapid

antigen test: a prospective multi-centre analytical and clinical evaluation. Wellcome Open Research 2021;**6**:132.

194. Kawser Z, Hossain M, Suliman S, Lockman S, Gitaka J, Bandawe G, et al. An assessment of a rapid SARS-cov-2 antigen test in Bangladesh. *American Journal of Tropical Medicine and Hygiene* 2022;**107**(4):845-9. [DOI: 10.4269/ajtmh.22-0068]

195. Kawser Z, Hossain M, Suliman S, Lockman S, Gitaka J, Bandawe G, et al. An assessment of a rapid SARS-CoV-2 antigen test in Bangladesh. MedRxiv (Preprint) 202110.1101/2021.10.05.21264551.

196. Muthamia E, Mungai S, Mungai M, Bandawe G, Qadri F, Kawser Z, et al. Assessment of performance and implementation characteristics of rapid point of care SARS-CoV-2 antigen testing. *AAS Open Research* 2022;**5**:13323.1.

197. Muthamia E, Mungai S, Mungai M, Bandawe G, Qadri F, Kawser Z, et al. Assessment of performance and implementation characteristics of rapid point of care SARS-CoV-2 antigen testing in Kenya [Preprint]. MedRxiv: the Preprint Server for Health Sciences 202110.1101/2021.1106.1103.21258290. [DOI: 10.1101/2021.1106.1103.21258290]

198. Kawser Z, Hossain M, Suliman S, Lockman S, Gitaka J, Bandawe G, et al. An assessment of a rapid SARS-cov-2 antigen test in Bangladesh. *American Journal of Tropical Medicine and Hygiene* 2022;**107**(4):845-9. [DOI: 10.4269/ajtmh.22-0068]

199. Kawser Z, Hossain M, Suliman S, Lockman S, Gitaka J, Bandawe G, et al. An assessment of a rapid SARS-CoV-2 antigen test in Bangladesh. MedRxiv (Preprint) 202110.1101/2021.10.05.21264551.

200. Venekamp RP, Veldhuijzen IK, Moons KGM, Van den Bijllaardt W, Pas SD, Lodder EB, et al. Detection of SARS-CoV-2 infection in the general population by three prevailing rapid antigen tests: cross-sectional diagnostic accuracy study. *BMC Medicine* 2022;**20**(1):97.

201. Kurihara Y, Kiyasu Y, Akashi Y, Takeuchi Y, Narahara K, Mori S, et al. The evaluation of a novel digital immunochromatographic assay with silver amplification to detect SARS-CoV-2. *Journal of Infection and Chemotherapy* 2021;**27**(10):1493-7. [DOI: 10.1016/j.jiac.2021.07.006]

202. Kurihara Y, Kiyasu Y, Akashi Y, Takeuchi Y, Narahara K, Mori S, et al. The evaluation of a novel digital immunochromatographic assay with silver amplification to detect SARS-CoV-2. MedRxiv [Preprint] 20212021.05.06.21256738. [DOI: 10.1101/2021.05.06.21256738]

203. Allan-Blitz LT, Klausner JD. A real-world comparison of SARS-CoV-2 rapid antigen versus polymerase chain reaction testing in Florida. *Journal of Clinical Microbiology* 2021;**59**(10):e0110721.

204. Fitoussi F, Tonen-Wolyec S, Awaida N, Dupont R, Belec L. Analytical performance of the point-of-care BIOSYNEX COVID-19 Ag BSS for the detection of SARS-CoV-2 nucleocapsid protein in nasopharyngeal swabs: a prospective field evaluation during the COVID-19 third wave in France. Infection 2021;**50**(4):625-33.

205. Ford L, Whaley MJ, Shah MM, Salvatore PP, Segaloff HE, Delaney A, et al. Antigen test performance among children and adults at a SARS-CoV-2 community testing site. *Journal of the Pediatric Infectious Diseases Society* 2021;**10**(12):1052-61.

206. Jakobsen KK, Jensen JS, Todsen T, Tolsaard MG, Kirkby N, Lippert F, et al. Accuracy and cost description of rapid antigen test compared with reverse transcriptase-polymerase chain reaction for SARS-CoV-2 detection. *Danish Medical Journal* 2021;**68**(7):A03210217.

207. Jakobsen KK, Jensen JS, Todsen T, Lippert F, Martel CJ-M, Klokker M, et al. Detection of SARS-CoV-2 infection by rapid antigen test in comparison with RT-PCR in a public setting. MedRxiv[Preprint] 20212021.01.22.21250042. [DOI: 10.1101/2021.01.22.21250042]

208. Jegerlehner S, Suter-Riniker F, Jent P, Bittel P, Nagler M. Diagnostic accuracy of a SARS-CoV-2 rapid antigen test in real-life clinical settings: antigen tests in real-life clinical settings. International Journal of Infectious Diseases 2021;**109**:118-22.

209. King C, Lista-de Weever E, Henry M, Steingrover R, Fleming C, Panneflek R, et al. Validation of the Panbio COVID-19 Antigen Rapid Test (Abbott) to screen for SARS-CoV-2 infection in Sint Maarten: a diagnostic accuracy study. MedRxiv (Preprint) 202110.1101/2021.09.23.21260526.

210. Pena M, Ampuero M, Garces C, Gaggero A, Garcia P, Velasquez MS, et al. Performance of SARS-CoV-2 rapid antigen test compared with real-time RT-PCR in asymptomatic individuals. *International Journal of Infectious Diseases* 2021;**107**:201-4.

211. Pollock NR, Jacobs JR, Tran K, Cranston AE, Smith S, O'Kane CY, et al. Performance and implementation evaluation of the Abbott BinaxNOW Rapid Antigen test in a high-throughput drive-through community testing site in Massachusetts. *Journal of Clinical Microbiology* 2021;**59**(5):e00083-21.

212. Pollock NR, Tran K, Jacobs JR, Cranston AE, Smith S, O'Kane CY, et al. Performance and operational evaluation of the Access Bio CareStart Rapid Antigen test in a high-throughput drive-through community testing site in Massachusetts. *Open Forum Infectious Diseases* 2021;**8**(7):ofab243. [DOI: 10.1093/ofid/ofab243]

213. Salcedo N, Sena BF, Qu X, Herrera BB. Comparative evaluation of rapid isothermal amplification and antigen assays for screening testing of SARS-Cov-2. *Viruses* 2022;**14**(3):468. [DOI: 10.3390/v14030468]

214. Salcedo N, Sena BF, Qu X, Herrera BB. Comparative evaluation of rapid isothermal amplification and antigen assays for screening testing of SARS-CoV-2. MedRxiv [Preprint] 202110.1101/2021.12.16.21267796.

215. Schrom J, Marquez C, Pilarowski G, Wang G, Mitchell A, Puccinelli R, et al. Comparison of SARS-cov-2 reverse transcriptase polymerase chain reaction and Binaxnow rapid antigen tests at a community site during an omicron surge. *Annals of Internal Medicine* 2022;**175**(5):682-90.

216. Schuit E, Venekamp RP, Veldhuijzen IK, Van den Bijllaardt W, Pas SD, Stohr J, et al. Accuracy and usability of saliva and nasal rapid antigen self-testing for detection of SARS-CoV-2 infection in the general population: a head-to-head comparison. MedRxiv [Preprint] 20212021.12.08.21267452. [DOI: 10.1101/2021.12.08.21267452]

217. Schuit E, Venekamp RP, Veldhuijzen IK, Van den Bijllaardt W, Pas SD, Stohr J, et al. Accuracy and usability of saliva and nasal rapid antigen self-testing for detection of SARS-CoV-2 infection in the general population: a head-to-head comparison. MedRxiv [Preprint] 202110.1101/2021.12.08.21267452.

218. Sood N, Shetgiri R, Rodriguez A, Jimenez D, Treminino S, Daflos, et al. Evaluation of the Abbott BinaxNOW rapid antigen test for SARS-CoV-2 infection in children: implications for screening in a school setting. *PloS One* 2021;**16**(4):e0249710.

219. Suliman S, Matias WR, Fulcher IR, Molano FJ, Collins S, Uceta E, et al. Evaluation of the Access Bio CareStart rapid SARS-CoV-2 antigen test in asymptomatic individuals tested at a community mass-testing program in Western Massachusetts. *Scientific Reports* 2022;**12**(1):21338. [DOI: 10.1038/s41598-022-25266-3]

220. Suliman S, Matias WR, Fulcher IR, Molano FJ, Collins S, Uceta E, et al. Evaluation of the Access Bio CareStart rapid SARS-CoV-2 antigen test in asymptomatic individuals tested at a community mass-testing program in Western Massachusetts. MedRxiv [Preprint] 20212021.06.17.21259109. [DOI: 10.1101/2021.06.17.21259109]

221. Wertenauer C, Brenner-Michael G, Dressel A, Pfeifer C, Hauser U, Wieland E, et al. Diagnostic performance of rapid antigen testing for SARS-Cov-2: the Covid-19 antigen (COVAG) study. *Frontiers in Medicine* 2022;**9**:774550. [DOI: 10.3389/fmed.2022.774550]

222. Wertenauer C, Brenner-Michael G, Dressel A, Pfeifer C, Hauser U, Wieland E, et al. Diagnostic efficacy of rapid antigen testing for SARS-Cov-2: the Covid-19 antigen (COVAG) study. MedRxiv (Preprint) 202110.1101/2021.08.04.21261609.

223. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating the sensitivity of nasal or throat swabs: combination of both swabs increases the sensitivity of SARS-cov-2 rapid antigen tests. *Microbiology Spectrum* 2022;**10**(4):e00217-22. [DOI: 10.1128/spectrum.00217-22]

224. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating sensitivity of nasal or throat (ISNOT): a combination of both swabs increases sensitivity of SARS-CoV-2 rapid antigen tests. MedRxiv [Preprint] 202210.1101/2022.01.18.22269426.

225. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating the sensitivity of nasal or throat swabs: combination of both swabs increases the sensitivity of SARS-cov-2 rapid antigen tests. *Microbiology Spectrum* 2022;**10**(4):e00217-22. [DOI: 10.1128/spectrum.00217-22]

226. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating sensitivity of nasal or throat (ISNOT): a combination of both swabs increases sensitivity of SARS-CoV-2 rapid antigen tests. MedRxiv [Preprint] 202210.1101/2022.01.18.22269426.

227. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating sensitivity of nasal or throat (ISNOT): a combination of both swabs increases sensitivity of SARS-CoV-2 rapid antigen tests. MedRxiv [Preprint] 202210.1101/2022.01.18.22269426.

228. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating the sensitivity of nasal or throat swabs: combination of both swabs increases the sensitivity of SARS-cov-2 rapid antigen tests. *Microbiology Spectrum* 2022;**10**(4):e00217-22. [DOI: 10.1128/spectrum.00217-22]

229. Wertenauer C, Brenner-Michael G, Dressel A, Pfeifer C, Hauser U, Wieland E, et al. Diagnostic performance of rapid antigen testing for SARS-Cov-2: the Covid-19 antigen (COVAG) study. *Frontiers in Medicine* 2022;**9**:774550. [DOI: 10.3389/fmed.2022.774550]

230. Wertenauer C, Brenner-Michael G, Dressel A, Pfeifer C, Hauser U, Wieland E, et al. Diagnostic efficacy of rapid antigen testing for SARS-CoV-2: the COVid-19 AntiGen (COVAG) study. MedRxiv (Preprint) 202110.1101/2021.08.04.21261609. [DOI: 10.1101/2021.08.04.21261609]

231. Pilarowski G, Lebel P, Sunshine S, Liu J, Crawford E, Marquez C, et al. Performance characteristics of a rapid SARS-CoV-2 antigen detection assay at a public plaza testing site in San Francisco. *Journal of Infectious Diseases* 2021;**23**(7):1139-44. [EMBASE: https://doi.org/10.1093/infdis/jiaa802]

232. Pilarowski G, Lebel P, Sunshine S, Liu J, Crawford E, Marquez C, et al. Performance characteristics of a rapid SARS-CoV-2 antigen detection assay at a public plaza testing site in San Francisco. MedRxiv [Preprint] 20202020.11.02.20223891. [EMBASE: 10.1101/2020.11.02.20223891]

233. Siddiqui ZK, Chaudhary M, Robinson ML, McCall AB, Peralta R, Esteve R, et al. Implementation and accuracy of Binaxnow rapid antigen COVID-19 test in asymptomatic and symptomatic populations in a high-volume self-referred testing site. Microbiology Spectrum 2021;**9**(3):e0100821.

234. Sun KJ, Vaeth MJ, Robinson M, Elhabashy M, Gupta I, Purekal S, et al. High sensitivity and NPV for Binaxnow rapid antigen test in children at a mass testing site during prevalent Delta variant period. *Microbiology Spectrum* 2022;**10**(4):e00236-22. [DOI: 10.1128/spectrum.00236-22]

235. Sun KJ, Vaeth MJ, Robinson ML, Elhabashy M, Gupta I, Purekal S, et al. High sensitivity and NPV for Binaxnow rapid antigen test in children at a mass testing site during prevalent Delta variant. MedRxiv [Preprint] 202210.1101/2022.01.05.22268788.

236. Takeuchi Y, Akashi Y, Kiyasu Y, Terada N, Kurihara Y, Kato D, et al. A prospective evaluation of diagnostic performance of a combo rapid antigen test QuickNavi-Flu+COVID19 Ag. *Journal of Infection and Chemotherapy* 2022;**28**(6):840-3. [DOI: 10.1016/j.jiac.2022.02.027]

237. Takeuchi Y, Akashi Y, Kiyasu Y, Terada N, Kurihara Y, Kato D, et al. Clinical evaluation of a combo rapid antigen test QuickNavi-Flu+COVID19 Ag for simultaneous detection of SARS-CoV-2 and influenza viruses. MedRxiv [Preprint] 20212021.12.05.21267215. [DOI: 10.1101/2021.12.05.21267215]

238. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for severe acute respiratory syndrome Coronavirus 2 in close contacts of individuals with confirmed infection: performance and operational considerations. *Journal of Infectious Diseases* 2022;**226**(12):2118-28. [DOI: 10.1093/infdis/jiac204]

239. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for SARS-CoV-2 in close contacts of individuals with confirmed infection: performance and operational considerations. MedRxiv [Preprint] 202210.1101/2022.01.27.22269904. [DOI: 10.1101/2022.01.27.22269904]

240. Tonen-Wolyec S, Dupont R, Awaida N, Batina-Agasa S, Hayette MP, Belec L. Evaluation of the practicability of Biosynex antigen self-test Covid-19 Ag+ for the detection of Sars-Cov-2 nucleocapsid protein from self-collected nasal mid-turbinate secretions in the general public in France. *Diagnostics* 2021;**11**(12):2217.

241. Venekamp RP, Veldhuijzen IK, Moons KG, Van den Bijllaardt W, Pas SD, Lodder EB, et al. Detection of SARS-CoV-2 infection in the general population by three prevailing rapid antigen tests: cross-sectional diagnostic accuracy study. BMC Medicine 2022;**20**(1):97.

242. Venekamp RP, Veldhuijzen IK, Moons KGM, Van den Bijllaardt W, Pas SD, Lodder EB, et al. Detection of SARS-CoV-2 infection in the general population by three prevailing rapid antigen tests: cross-sectional diagnostic accuracy study. *BMC Medicine* 2022;**20**(1):97.

243. Venekamp RP, Veldhuijzen IK, Moons KGM, Van den Bijllaardt W, Pas SD, Lodder EB, et al. Detection of SARS-CoV-2 infection in the general population by three prevailing rapid antigen tests: cross-sectional diagnostic accuracy study. *BMC Medicine* 2022;**20**(1):97.

244. Agulló V, Fernández-González M, Ortiz de la Tabla V, Gonzalo-Jiménez N, García JA, Masiá M, et al. Evaluation of the rapid antigen test Panbio COVID-19 in saliva and nasal swabs in a population-based point-of-care study. *Journal of Infection* 2021;**82**(5):186-230.

245. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for severe acute respiratory syndrome Coronavirus 2 in close contacts of individuals with confirmed infection: performance and operational considerations. *Journal of Infectious Diseases* 2022;**226**(12):2118-28. [DOI: 10.1093/infdis/jiac204]

246. Zobrist S, Oliveira-Silva M, Vieira AM, Bansil P, Gerth-Guyette E, Leader BT, et al. Screening for SARS-CoV-2 in close contacts of individuals with confirmed infection: performance and operational considerations. MedRxiv [Preprint] 202210.1101/2022.01.27.22269904. [DOI: 10.1101/2022.01.27.22269904]

247. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating the sensitivity of nasal or throat swabs: combination of both swabs increases the sensitivity of SARS-cov-2 rapid antigen tests. *Microbiology Spectrum* 2022;**10**(4):e00217-22. [DOI: 10.1128/spectrum.00217-22]

248. Goodall BL, LeBlanc JJ, Hatchette TF, Barrett L, Patriquin G. Investigating sensitivity of nasal or throat (ISNOT): a combination of both swabs increases sensitivity of SARS-CoV-2 rapid antigen tests. MedRxiv [Preprint] 202210.1101/2022.01.18.22269426.

249. Schildgen V, Demuth S, Lüsebrink J, Schildgen O. Limits and opportunities of SARS-CoV-2 antigen rapid tests: an experience-based perspective. *Pathogens* 2021;**10**(1):38. [DOI: 10.3390/pathogens10010038]

250. Schildgen V, Demuth S, Lüsebrink J, Schildgen O. Limits and opportunities of SARS-CoV-2 antigen rapid tests: an experience-based perspective. *Pathogens* 2021;**10**(1):38. [DOI: 10.3390/pathogens10010038]

251. Klein JA, Kruger LJ, Tobian F, Gaeddert M, Lainati F, Schnitzler P, et al. Head-to-head performance comparison of self-collected nasal versus professional-collected nasopharyngeal swab for a WHO-listed SARS-CoV-2 antigen-detecting rapid diagnostic test. *Medical Microbiology and Immunology* 2021;**210**(4):181-6.

252. Le Goff J, Kerneis S, Elie C, Mercier-Delarue S, Gastli N, Choupeaux L, et al. Evaluation of a saliva molecular point of care for the detection of SARS-CoV-2 in ambulatory care. *Scientific Reports* 2021;**11**(1):21126. [DOI: 10.1038/s41598-021-00560-8]

253. Le Goff J, Kerneis S, Elie C, Mercier D, Gastli N, Choupeaux L, et al. Evaluation of saliva molecular point of care for detection of SARS-CoV-2 in ambulatory care. MedRxiv [Preprint] 20212021.06.12.21258811. [DOI: 10.1101/2021.06.12.21258811]

254. Venekamp RP, Veldhuijzen IK, Moons KGM, Van den Bijllaardt W, Pas SD, Lodder EB, et al. Detection of SARS-CoV-2 infection in the general population by three prevailing rapid antigen tests: cross-sectional diagnostic accuracy study. *BMC Medicine* 2022;**20**(1):97.

255. Caruana G, Croxatto A, Kampouri E, Kritikos A, Opota O, Foerster M, et al. Implementing SARS-CoV-2 rapid antigen testing in the emergency ward of a Swiss university hospital: the INCREASE study. *Microorganisms* 2021;**9**(4):798.

256. Caruana G, Croxatto A, Kampouri E, Kritikos A, Opota O, Foerster M, et al. Implementing SARS-CoV-2 rapid antigen testing in the emergency ward of a Swiss university hospital: the INCREASE study. *Microorganisms* 2021;**9**(4):798.

257. Caruana G, Croxatto A, Kampouri E, Kritikos A, Opota O, Foerster M, et al. Implementing SARS-CoV-2 rapid antigen testing in the emergency ward of a Swiss university hospital: the INCREASE study. *Microorganisms* 2021;**9**(4):798.

258. Drevinek P, Hurych J, Kepka Z, Briksi A, Kulich M, Zajac M, et al. The sensitivity of SARS-CoV-2 antigen tests

in the view of large-scale testing. MedRxiv [Preprint] 20202020.11.23.20237198. [DOI: 10.1101/2020.11.23.20237198]

259. Kiyasu Y, Takeuchi Y, Akashi Y, Kato D, Kuwahara M, Muramatsu S, et al. Prospective analytical performance evaluation of the QuickNavi™-COVID19 Ag for asymptomatic individuals. *Journal of Infection and Chemotherapy* 2021;**27**(10):1489-92. [DOI: 10.1016/j.jiac.2021.07.005]

260. Kiyasu Y, Takeuchi Y, Akashi Y, Kato D, Kuwahara M, Muramatsu S, et al. Prospective analytical performance evaluation of the QuickNavi-COVID19 Ag for asymptomatic individuals. MedRxiv [Preprint] 202110.1101/2021.04.01.21254813. [DOI: 10.1101/2021.04.01.21254813]

261. Pandey AK, Mohanty A, Hada V, Rath RS, Kumar S, Kishore S, et al. Comparison of the rapid antigen testing method with RT-qpcr for the diagnosis of COVID-19. *Cureus* 2021;**13**(8):e17405.

262. Suzuki H, Akashi Y, Ueda A, Kiyasu Y, Takeuchi Y, Maehara Y, et al. Diagnostic performance of a novel digital immunoassay (RapidTesta SARS-CoV-2): a prospective observational study with nasopharyngeal samples. *Journal of Infection and Chemotherapy* 2022;**28**(1):78-81. [DOI: 10.1016/j.jiac.2021.10.024]

263. Suzuki H, Akashi Y, Ueda A, Kiyasu Y, Takeuchi Y, Maehara Y, et al. Diagnostic performance of a novel digital immunoassay (RapidTesta SARS-CoV-2): a prospective observational study with 1,127 nasopharyngeal samples. MedRxiv (Preprint) 202110.1101/2021.07.26.21261162.

264. Manten K, Katzenschlager S, Brummer LE, Schmitz S, Gaeddert M, Erdmann C, et al. Clinical accuracy of instrument-based SARS-CoV-2 antigen diagnostic tests: a systematic review and meta-analysis. *Virology Journal* 2024;**21**(1):99. [DOI: 10.1186/s12985-024-02371-5]

265. Brümmer LE, Katzenschlager S, McGrath S, Schmitz S, Gaeddert M, Erdmann C, et al. Accuracy of rapid point-of-care antigen-based diagnostics for SARS-CoV-2: an updated systematic review and meta-analysis with meta-regression analyzing influencing factors. *PLoS Medicine* 2022;**19**(5):e1004011. [DOI: 10.1371/journal.pmed.1004011]

266. Hirabayashi E, Mercado G, Hull B, Soin S, Koshy-Chenthittayil S, Raman S, et al. Comparison of diagnostic accuracy of rapid antigen tests for COVID-19 compared to the viral genetic test in adults: a systematic review and meta-analysis. *Joanna Briggs Institute Evidence Synthesis* 2024;**22**(10):1939-2002. [DOI: 10.11124/JBIES-23-00291]

267. Binnicker MJ. Challenges and controversies to testing for COVID-19. *Journal of Clinical Microbiology* 2020;**58**(11):e01695-20.

268. Infectious Diseases Society of America, Assocation for Molecular Pathology. IDSA and AMP joint statement on the use of SARS-CoV-2 PCR cycle threshold (Ct) values for clinical decision-making; 12 March 2021. www.idsociety.org/globalassets/idsa/public-health/covid-19/idsa-amp-statement.pdf (accessed prior to 9 October 2025).

269. Deeks JJ, Singanayagam A, Houston H, Sitch AJ, Hakki S, Dunning J, et al. SARS-CoV-2 antigen lateral flow tests for detecting infectious people: linked data analysis. *BMJ (Clinical Research Ed.)* 2022;**376**:e066871.

270. Walsh KA, Broderick N, Ahern S, Fawsitt CG, O'Brien KM, Carrigan M, et al. Effectiveness of rapid antigen testing for screening of asymptomatic individuals to limit the transmission of SARS-CoV-2: a rapid review. *Reviews in Medical Virology* 2022;**32**(5):e2350. [DOI: 10.1002/rmv.2350]

271. Chen CC, Chen SY, Fang SB, Lu SC, Bai CH, Wang YH. Diagnostic accuracy of SARS-CoV-2 antigen test in the pediatric population: a systematic review and meta-analysis. *Pediatrics and Neonatology* 2023;**64**(3):247-55. [DOI: 10.1016/j.pedneo.2022.07.012]

272. Fragkou PC, Moschopoulos CD, Dimopoulou D, Ong DS, Dimopoulou K, Nelson PP, et al. Performance of point-of care molecular and antigen-based tests for SARS-CoV-2: a living systematic review and meta-analysis. *Clinical Microbiology and Infection* 2023;**29**(3):291-301. [DOI: 10.1016/j.cmi.2022.10.028]

273. Tapari A, Braliou GG, Papaefthimiou M, Mavriki H, Kontou PI, Nikolopoulos GK, et al. Performance of antigen detection tests for SARS-Cov-2: a systematic review and meta-analysis. *Diagnostics* 2022;**12**(6):1388.

274. Meyerowitz EA, Richterman A, Bogoch II, Low N, Cevik M. Towards an accurate and systematic characterisation of persistently asymptomatic infection with SARS-CoV-2. *Lancet Infectious Diseases* 2020;**21**(8):E163-29. [DOI: 10.1016/S1473-3099(20)30837-9]

275. Smith RL, Gibson LL, Martinez PP, Ke R, Mirza A, Conte M, et al. Longitudinal assessment of diagnostic test performance over the course of acute SARS-CoV-2 infection. *Journal of Infectious Diseases* 2021;**224**(6):976-82. [DOI: 10.1093/infdis/jiab337]

276. Moreno GK, Braun KM, Pray IW, Segaloff HE, Lim A, Poulsen K, et al. SARS-CoV-2 transmission in intercollegiate athletics not fully mitigated with daily antigen testing. *Clinical Infectious Diseases* 2021;**73**(Suppl 1):S45-S53.

277. Bell KJ, Li Y, Medcalf E, Ackermann D. COVID-19 rapid antigen tests approved for self-testing in Australia: published diagnostic test accuracy studies and manufacturer-supplied information. A systematic review. *Medical Journal of Australia* 2023;**219**(11):551-8. [DOI: 10.5694/mja2.52151]

278. Bigio J, MacLean EL, Das R, Sulis G, Kohli M, Berhane S, et al. Accuracy of package inserts of SARS-CoV-2 rapid antigen tests: a secondary analysis of manufacturer versus systematic review data. *Lancet. Microbe* 2023;**4**(11):e875-e82. [DOI: 10.1016/s2666-5247(23)00222-7]

279. Baylis SA, Wallace P, McCulloch E, Niesters HG, Nübling CM. Standardization of nucleic acid tests: the approach of the World Health Organization. *Journal of Clinical Microbiology* 2019;**57**(1):e01056-18. [DOI: 10.1128/JCM.01056-18] [PMID: 30257900]

280. Royal Statistical Society. Royal Statistical Society Diagnostic Tests Working Group Report. London: Royal Statistical Society, 2021.

281. Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. *BMJ (Clinical Research Ed.)* 2015;**351**:h5527. [DOI: 10.1136/bmj.h5527] [PMID: 26511519]

282. Review Manager (RevMan). Version 8.7.0. The Cochrane Collaboration, 2024. Available at https://revman.cochrane.org.

ADDITIONAL TABLES

Table 1. Description of studies

		No. of studies/test evaluations (%)
Participants		
Number of studies		**146**
Sample size	Median (IQR)	466 (145, 874)
	Range	(10, 22,994)
	Total	147,178
Number of COVID-19 cases	Median (IQR)	31 (14, 59)
	Range	(0, 958)
	Total	7104
Setting	COVID-19 test centre	64 (43.8)
	ED/Urgent care	11 (7.5)
	Hospital-based (all)	24 (16.4)
	Any (patient, visitor or staff)	*10 (41.7)*
	Any patient (inpatient or outpatient)	*3 (12.5)*
	Inpatient	*9 (37.5)*
	Outpatient	*2 (8.3)*
	Screening (all)	30 (20.6)
	School/university	*15 (50.0)*
	HCW	*4 (13.3)*
	Community	*4 (13.3)*
	Traveller	*2 (6.7)*
	Other targeted screening	*5 (16.7)*
	Shared living facility (nursing homes)	4 (2.7)
	Quarantine	1 (0.7)

Table 1. Description of studies *(Continued)*

	Laboratory-based	3 (2.1)
	Multiple settings	6 (4.1)
	Unclear	3 (2.1)
Symptom status	Asymptomatic – any	94 (64.4)
	Asymptomatic – contacts	39 (26.7)
	Asymptomatic – no details	8 (5.5)
	Mainly asymptomatic (≥ 75%)	5 (3.4)
Age		
Studies allowing within-study comparison with adults	Paediatric < 16 y	1 (40.0)
	Paediatric < 18 y	5 (40.0)
Study design		
Recruitment structure (intended as)	Single group – sensitivity and specificity	134 (91.8)
	Two or more groups – sensitivity and specificity	5 (3.4)
	Single group – sensitivity only	4 (2.7)
	Randomised trial	2 (1.4)
	Unclear	1 (0.7)
Reference standard		
for COVID-19 cases	Single RT-PCR positive	146 (100.0)
for non-COVID-19 cases	Single RT-PCR negative	141 (96.6)
	Double RT-PCR negative (COVID-19 suspects)	1 (0.7)
	Cases only study	4 (2.7)
Reference test sample		
	Paired; same site as for index test	82 (56.2)
	Paired; alternative site to index	46 (31.5)
	Paired; NP	*19 (41.3)*
	Paired; NP + OP	*10 (21.7)*
	Paired; OP	*8 (17.4)*
	Paired; Nasal + OP	*4 (8.7)*

Table 1. Description of studies *(Continued)*

	Paired; combinations of NP, OP, AN	*3 (6.5)*
	Paired; gargle	*1 (2.2)*
	Paired; oral fluid/saliva	*1 (2.2)*
	Same sample used	16 (11.0)
	Unclear; same sample type	2 (1.4)
Tests		
Number of evaluations per study	Single assay evaluated	140 (95.9)
	Two assays compared	3 (2.1)
	Three assays compared	1 (0.7)
	Four assays compared	1 (0.7)
	Five assays compared	1 (0.7)
	Sample types compared	6 (4.1)
Total number of test evaluations		**164**
Test method	CGIA	121 (73.8)
	FIA	11 (6.7)
	LFA (ALP)	1 (0.6)
	LFA (latex conjugated)	4 (2.4)
	LFA (nos)	20 (12.2)
	Microfluidic FIA	7 (4.3)
Sample type	NP alone	84 (51.2)
	NP + OP	6 (3.7)
	NP or OP	3 (1.8)
	Nasal	52 (31.7)
	Nasal (AN)	*32 (61.5)*
	Nasal (NMT)	*7 (13.5)*
	Nasal (nos)	*13 (25.0)*
	Nasal + OP	6 (3.7)
	Saliva	4 (2.4)

Table 1. Description of studies *(Continued)*

	Not specified	1 (0.6)
	Other*	8 (4.9)
Sample storage	Direct	137 (83.5)
	VTM	15 (9.2)
	Direct or VTM	1 (0.6)
	Saline	1 (0.6)
	Not specified	10 (6.1)
Sample collection	HCW	63 (38.4)
	Self-collected	24 (14.6)
	Trained non-HCW	15 (9.1)
	Trained 'personnel'	8 (4.9)
	Laboratory scientist	5 (3.0)
	Mixed	3 (1.8)
	Not specified	46 (28.0)
Sample testing	HCW	44 (26.8)
	Laboratory scientist	25 (15.2)
	Trained 'personnel'	24 (14.6)
	Trained non-HCW	5 (3.1)
	Self-tested	7 (4.3)
	Not specified (lab-based)	16 (9.8)
	Not specified (on-site)	41 (25.0)
	Not specified	2 (1.2)
IFU compliance	Yes	117 (71.3)
	No	33 (20.1)
	Unclear	14 (8.5)
Secondary analyses regardless of symptom status (variable denominator)		
Age (for studies allowing within-study comparison with adults)	Paediatric < 18 y	2 (50.0)
	Paediatric < 12 y or < 14 y	2 (50.0)

Table 1. Description of studies *(Continued)*

Variant confirmed (excludes presumptive associations by time period)	Alpha	3 studies; 4 evaluations
	Omicron	3 studies; 5 evaluations
Method of variant confirmation	S-gene dropout only	5 (55.6) 1 (Alpha; 4 Omicron)
	PCR variant kit	2 (22.2) (Alpha)
	Typing (nos)	1 (11.1) (Alpha)
	Whole genome sequencing	1 (11.1) (Omicron)

ALP: alkaline phosphatase
AN: anterior nasal
CGIA: colloidal gold immunoassay
ED: emergency department
FIA: fluorescent immunoassay
HCW: healthcare worker
IFU: instructions for use
IQR: interquartile range
LFA: lateral flow assay
NMT: nasal midturbinate
NP: nasopharyngeal
OP: oropharyngeal
PCR: reverse transcription polymerase chain reaction
RT: reverse transcriptase
TA: throat aspirate
TS: throat saliva
TW: throat wash
VTM: viral transport medium

Table 2. Summary of sensitivity and specificity results

Test	Evaluations	Total number of samples	Number of cases (sub-group of the total samples)	**Summary sensitivity, % (95% CI)**	***Difference in sensitivity, (95% CI), P value***	**Summary specificity, % (95% CI)**	***Difference in specificity, (95% CI), P value***
Primary analysis (including "mainly asymptomatic")							
All studies reporting sensitivity and specificity	147	149,251	7636	55.0 (50.9, 59.0)	-	99.5 (99.5, 99.6)	-
All data for sensitivity (including 'sensitivity-only' evaluations)	158	149,716	8101	54.0 (50.0, 57.9)	-	-	-
All data for specificity (including 'specificity-only' cohort)	153	152,164	7636	-	-	99.5 (99.5, 99.6)	-
Secondary analysis by reported exposure to SARS-CoV-2							
Any person tested regardless of reported exposure	103	129,032	5660	53.0 (48.4, 57.5)	*Ref*	99.6 (99.5, 99.6)	*Ref*
Contacts/exposure reported	43	15,516	1483	58.6 (51.4, 65.5)	*5.7 (-2.8, 14.1), P = 0.187*	99.4 (99.2, 99.5)	*-0.2 (-0.4, -0.08), P = 0.002*
Mainly asymptomatic	23	42,130	2740	61.5 (52.8, 69.5)	*8.5 (-1.1, 18.1), P = 0.082*	99.5 (99.5, 99.6)	*-0.05 (-0.1, 0.03), P = 0.242*
Within-study comparison by reported exposure							
Contacts/exposure reported	6	3683	123	66.1 (44.9, 82.4)	*Ref*	99.6 (99.3, 99.8)	*Ref*
No exposure reported	6	14,567	159	58.5 (37.1, 77.1)	*-7.6 (-36.4, 21.2), P = 0.605*	99.9 (99.8, 99.9)	*0.2 (0.03, 0.5), P = 0.024*
Subgroup analyses							
By setting							
COVID-19 test centre	69	66,021	4482	56.7 (52.1, 61.2)	-	99.6 (99.5, 99.6)	-
ED/urgent care	10	8184	411	54.7 (34.1, 73.8)	-	98.9 (98.6, 99.1)	-

Table 2. Summary of sensitivity and specificity results *(Continued)*

Hospital					-	98.9 (98.6, 99.1)	-
any patient, visitor or staff	5	6019	358	61.8 (31.8, 84.9)	-	98.9 (98.6, 99.1)	-
in or outpatient	3	2519	117	52.0 (11.7, 89.8)	-	99.0 (98.5, 99.3)	-
inpatient	12	6245	291	39.8 (27.3, 53.8)	-	99.8 (99.6, 99.9)	-
outpatient	2	1206	85	34.1 (24.9, 44.8)	-	99.8 (99.3, 99.96)	-
Screening							
school or university	10	18,721	261	40.6 (29.7, 52.6)	-	99.7 (99.6, 99.8)	-
community	7	8034	648	42.1 (36.9, 47.5)	-	99.4 (99.2, 99.6)	-
HCW	4	3441	145	40.2 (3.6, 92.3)	-	99.9 (99.7, 99.97)	-
targeted screening	3	23,922	76	74.3 (50.3, 89.2)	-	99.9 (99.9, 99.95)	-
traveller	1	145	5	40.0 (5.3, 85.3)	-	100 (97.4, 100)	-
Nursing home	3	225	55	76.4 (63.4, 85.8)	-	95.9 (91.6, 98.0)	-
Quarantine	1	113	47	85.1 (71.7, 93.8)	-	100 (94.6, 100)	-
Mixed	5	712	122	69.8 (46.9, 85.8)	-	99.8 (98.8, 99.98)	-
Unclear	5	284	62	47.8 (28.3, 67.9)	-	77.8 (44.0, 94.0)	-
Laboratory-based	2	532	131	58.1 (21.7, 87.5)	-	98.8 (97.0, 99.5)	-
By time post contact							
Week 1	2	950	51	81.6 (51.8, 94.8)	*Ref*	99.7 (99.0, 99.9)	*Ref*
Week 2	2	429	29	65.5 (46.9, 80.3)	*-16.1 (-43.5, 11.3), P = 0.251*	99.8 (98.2, 99.96)	*0.1 (-0.5, 0.7), P = 0.791*
By viral load							
Higher VL: < 25 Ct	18	710	710	91.3 (83.1, 95.7)	*Ref*	-	-

Table 2. Summary of sensitivity and specificity results *(Continued)*

Lower VL: > 25 Ct	18	653	653	19.0 (10.1, 32.8)	*-72.3 (-79.4, -65.1), P < 0.0001*	-	-
Subgroup: 25-30 Ct	13	248	248	50.9 (25.8, 75.5)	-	-	-
Higher VL: < 30 Ct	25	1176	1176	75.5 (65.0, 83.6)	*Ref*	-	-
Lower VL: > 30 Ct	25	762	762	14.6 (9.7, 21.4)	*-60.8 (-71.9, -49.8), P < 0.0001*	-	-
By age (within-study comparisons; asymptomatic only)							
Children – direct comparison	5	8855	250	51.6 (42.7, 60.4)	*Ref*	99.7 (99.6, 99.8)	*Ref*
Adults – direct comparison	5	9486	801	57.4 (50.1, 64.3)	*5.7 (-6.0, 17.5), P = 0.339*	99.7 (99.6, 99.8)	*-0.02 (-0.2, 0.1), P = 0.797*
By sample type							
Includes NP (all; NP alone or NP and OP combined sample)	80	46,336	3340	52.8 (47.7, 58.0)	*Ref*	99.4 (99.3, 99.5)	*Ref*
Nasal (all; AN, NMT or not specified)	44	84,207	3332	59.8 (53.0, 66.2)	*6.9 (-1.5, 15.4), P = 0.107*	99.6 (99.6, 99.6)	*0.2 (0.1, 0.3), P < 0.0001*
Nasal + OP	6	9676	367	47.2 (29.3, 65.9)	*-5.6 (-25.5, 14.2), P = 0.579*	99.9 (99.8, 99.9)	*0.5 (0.3, 0.6), P < 0.0001*
Includes NP (some)	4	3328	81	67.7 (41.9, 85.9)	*14.9 (-9.0, 38.7), P = 0.222*	99.2 (98.8, 99.5)	*-0.2 (-0.5, 0.1), P = 0.168*
Saliva (all)	2	728	63	15.9 (4.7, 42.1)	*-37.0 (-55.7, -18.3), P < 0.0001*	99.8 (98.9, 99.98)	*0.4 (0.1, 0.7), P = 0.006*
OP alone	1	825	62	64.5 (51.3, 76.3)	-	100 (99.5, 100)	-
Other	5	1223	51	42.8 (21.2, 67.5)	-	95.4 (45.2, 99.8)	-
By sample type: within-study comparisons (no statistical comparisons conducted)							

Table 2. Summary of sensitivity and specificity results *(Continued)*

NP[a]	2	1029	84	70.6 (61.5, 78.6)	-	99.7 (99.0, 99.9)	-
versus nasal (any type)[a]	2	567	108	60.2 (50.3, 69.5)	-	99.8 (98.8, 100.0)	-
Nasal (any type)[a]	2	610	114	42.1 (32.9, 51.7)	-	100.0 (99.3, 100.0)	-
versus saliva[a]	2	584	112	25.9 (18.1, 35.0)	-	99.4 (98.2, 99.9)	-
Nasal (all)	1	825	62	64.5 (51.3, 76.3)	-	100 (99.5, 100)	-
versus OP alone	1	825	62	64.5 (51.3, 76.3)	-	100 (99.5, 100)	-
Nasal	1	520	38	68.4 (51.3, 82.5)	-	100 (99.2, 100)	-
versus NP + OP	1	520	38	81.6 (65.7, 92.3)	-	100 (99.2, 100)	-
By assay format							
CGIA	107	123,687	5734	53.4 (48.7, 58.1)	*Ref*	99.7 (99.7, 99.7)	*Ref*
FIA	10	11,200	291	46.2 (31.0, 62.2)	*-7.2 (-24.0, 9.6), P = 0.402*	98.8 (98.6, 99.0)	*-0.9 (-1.1, -0.7), P < 0.0001*
LFA (latex conjugated)	4	2773	320	66.6 (61.2, 71.5)	-	99.9 (99.6, 99.96)	-
LFA (nos)	16	7089	750	53.1 (42.3, 63.6)	-	98.9 (98.6, 99.1)	-
Microfluidic FIA	5	1574	201	78.8 (60.1, 90.1)	-	95.3 (94.0, 96.3)	-

ALP: alkaline phosphatase
AN: anterior nasal
CGIA: colloidal gold immunoassay
CI: confidence interval
Ct: cycle threshold
ED: emergency department
Ref: reference case
FIA: fluorescent immunoassay
HCW: healthcare worker
LFA: lateral flow assay
NMT: nasal midturbinate
NP: nasopharyngeal
OP: oropharyngeal
SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

Table 2. Summary of sensitivity and specificity results *(Continued)*

VL: viral load

[a]2x2 tables combined prior to calculating estimates