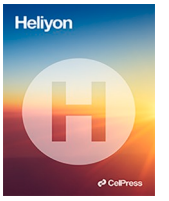
Heliyon 9 (2023) e22612

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Evaluation of the Panbio™ COVID-19 IgG rapid test device performance

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https://doi.org/10.1016/j.heliyon.2023.e22612
Received 30 August 2023; Received in revised form 13 November 2023; Accepted 15 November 2023
Available online 22 November 2023

A B S T R A C T

Background: The Panbio™ COVID-19 IgG Rapid Test Device ("Panbio™") detects IgG antibodies against the SARS-CoV-2 spike protein from viral infection or vaccination.
Objectives: To determine the diagnostic sensitivity and specificity of the Panbio™ professional use test, using fingerstick whole blood and venous plasma.
Study design: Fingerstick whole blood and venous plasma from each participant were tested with Panbio™ and compared against the SARS-CoV-2 IgG II assay on the Abbott Architect™ platform (Europe) or the equivalent AdviseDx SARS-CoV-2 IgG II Abbott Alinity i™ platform (US). 447 evaluable participants were enrolled across 6 US and 9 European clinical centers.
Results: For unvaccinated participants with PCR-confirmed infection ≥21 days post-symptom onset, the Panbio™ sensitivity with fingerstick whole blood was 92.6 % (95 % CI: 85.9, 96.7), and the specificity was 97.0 % (95 % CI: 93.1, 99.0). For venous plasma, the sensitivity was 90.0 % (95 % CI: 79.5, 96.2) for participants with PCR-confirmed infection and symptom onset 22–180 days ago; the specificity was 96.3 % (92.2, 98.6). For vaccinated participants, the sensitivity was 98.4 % (95 % CI: 91.2, 100.0) for fingerstick whole blood and 96.7 % (95 % CI: 88.7, 99.6) for venous plasma.
Conclusion: The Panbio™ test had high sensitivity and specificity for detecting IgG against the SARS-CoV-2 spike protein.

1. Introduction

Since COVID-19 was declared a pandemic by the World Health Organization (WHO) on March 11th, 2020, more than 757 million cases have been reported, including 6.85 million deaths [1]. Molecular tests, i.e., nucleic acid amplification tests (NAAT), are important for identifying SARS-CoV-2 infection [2]. Conversely, serological tests detect antibodies produced by a person who has had an immune response to SARS-CoV-2 as a result of infection and/or vaccination against COVID-19 [3]. Immunoglobulin M (IgM) and Immunoglobulin G (IgG) antibodies have been reported to appear almost simultaneously 1–2 weeks post-symptom onset (PSO) and appear to peak 11–14 days PSO [4]. Studies have shown that IgM antibodies can be detected 3–4 months PSO whereas IgG antibodies can last for at least 12 months after infection [5–7]. IgG antibodies against the spike protein are also present in those with immune responses due to vaccination [8]. Following infection, PCR-confirmed positive test result, and subsequent recovery, a certificate of recovery in the EU and an NHS travel pass from the UK are valid for six months [9,10].

The Common Specifications for certain class D *in vitro* diagnostic medical devices under Regulation (EU) 2017/746, of July 4, 2022, require a COVID-19 antibody test sensitivity of ≥90 % in those with PCR-confirmed infection and symptoms onset >21 days ago and a specificity of >99 % from individuals with no history of SARS-CoV-2 infection (if available pre-pandemic) [11].

The Panbio™ COVID-19 IgG Rapid Test Device ("Panbio™" Abbott Rapid Diagnostics Jena GmbH, Jena, Germany) is a rapid, lateral flow immunoassay intended for the qualitative detection of IgG antibodies to SARS-CoV-2 spike protein in human serum, plasma, venous whole blood and fingerstick whole blood samples. The assay is intended for use as an aid in identifying individuals with an adaptive immune response to SARS-CoV-2. It is intended for professional use and in a near-patient setting. Each Panbio™ test is performed with either 20 μL of whole blood, 10 μL of serum, or 10 μL of plasma, and two drops of buffer solution. The Panbio™ test results are interpreted between 10 and 20 min after buffer application; negative results must be confirmed at 20 min.

The primary study objective was to determine the diagnostic sensitivity and specificity of the Panbio™ test using fingerstick capillary whole blood and venous plasma from both vaccinated and unvaccinated individuals when the test is performed by professional users. The secondary objective was to evaluate matrix equivalence between fingerstick capillary whole blood and venous plasma when the Panbio™ test is performed by a professional user. The Panbio™ COVID-19 Antibody Self-Test was evaluated in the same trial; these results will be reported separately.

2. Materials and methods

2.1. Study procedures

After verifying that each participant met all study inclusion criteria and none of the exclusion criteria, study staff obtained written informed consent. Further details are given in the study registration ISRCTN10699017 (EU) and NCT04959760 (US) [12,13].

The intended population included individuals aged 16 years or older (UK), or 18 years or older (Spain, US), with a prior suspected or confirmed COVID-19 infection with or without symptoms. The intended population also included individuals who had received COVID-19 vaccine, 30 days or more after they had received their second vaccine dose, or first vaccine dose where applicable (26 CE. COV2.S vaccine, Johnson & Johnson). The exclusion criteria for the professional test evaluation were as follows: Participant has already participated in this study on a previous occasion; Participant is enrolled in a study to evaluate a new drug; Participant is unable or unwilling to provide informed consent; Participant is a vulnerable person as deemed unfit for the study by the Principal Investigator; Participant has a condition deemed unfit by the investigator to safely perform or receive the test. The intended population also included unvaccinated individuals not suspected of a past COVID-19 infection. Participant demographics, education level, and a brief medical history were recorded on source documents.

2.2. Sample Collection and testing

A study staff member collected a fingerstick capillary whole blood specimen for each participant tested with the Panbio™ test. The results were interpreted at 10, 15, and 20 min after buffer application by a study staff member who was blinded to the participant's presumed SARS-CoV-2 status, other SARS-COV-2 test results and vaccination status. Since negative results must be confirmed at 20 min, the performance data reported here are based on results interpreted at 20 min. Each result was photographed at the time of interpretation for workflow documentation purposes. Venipuncture was performed per the site's standard operating procedures; K2-EDTA anti-coagulant tubes were used and processed according to the *Instructions for Use* (IFU) of the Panbio™ test. The plasma samples were tested using the Panbio™ test, and the reference test. Samples that were positive by Panbio™ and negative by the reference test were further analyzed using the Elecsys® anti-SARS-CoV-2-S qualitative assay (Elecsys®; Roche Diagnostics International Ltd, Rotkreuz, Switzerland; "Elecsys®") and two commercially available CE-marked rapid tests.

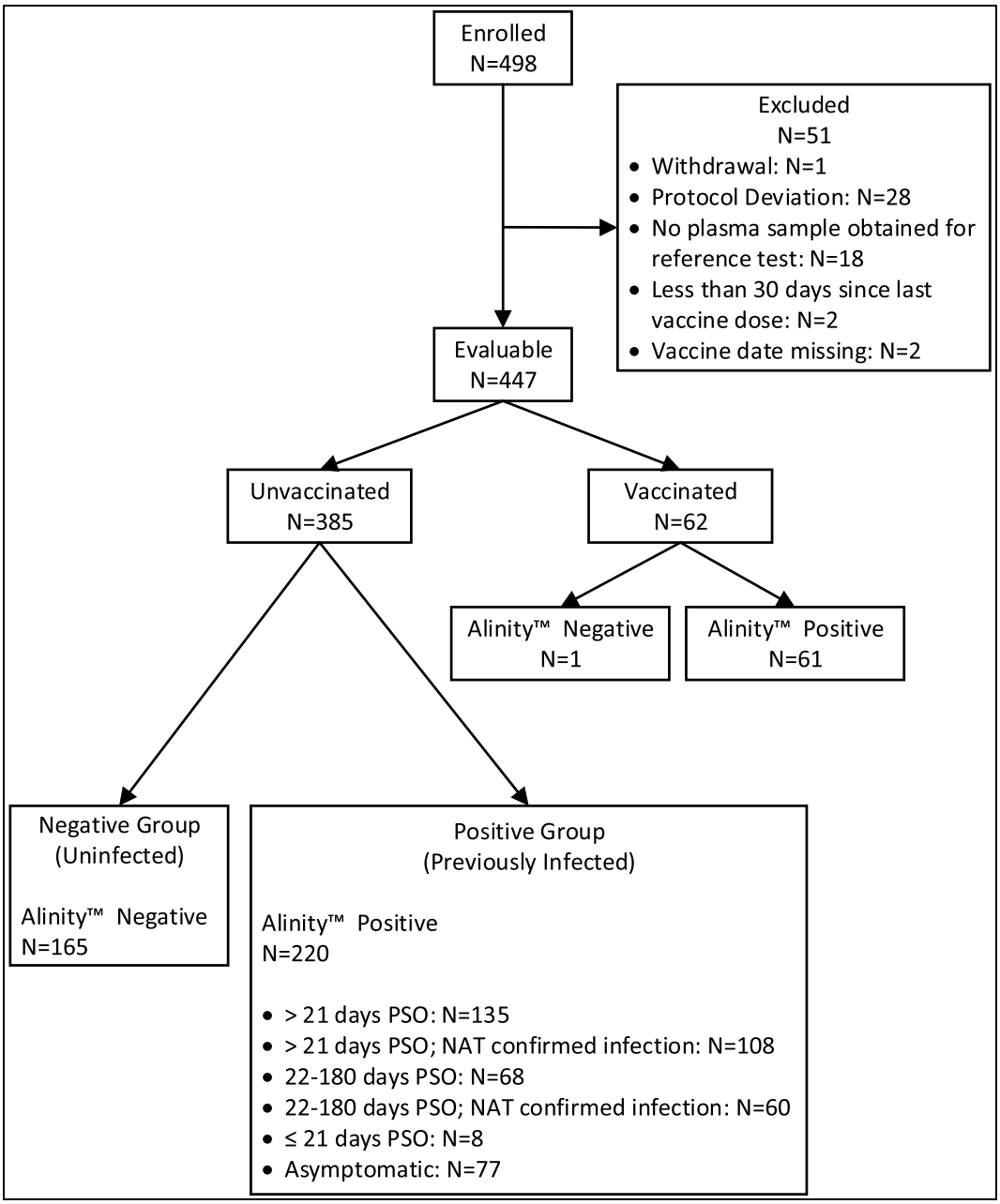

Fig. 1. Consort diagram reporting patient flow.

2.3. Tests

In the present study, all Panbio™ testing was conducted by healthcare professionals in a near-patient setting. The Panbio™ test results were compared against the SARS-CoV-2 IgG II assay performed on the Abbott Architect™ platform (Abbott Diagnostics, IL, USA) in Europe and the AdviseDx SARS-CoV-2 IgG II Abbott Alinity i™ (Abbott Diagnostics, IL, USA) platform in the US. The reference assays and the platforms are equivalent, and the reference test is hereafter referred to as Alinity i™. The study procedures, reference test, participants, and the operators using the Abbott tests were similar in both studies, and the data from the US and EU have been combined in this study analysis.

2.4. Statistical analysis

The sensitivity was calculated as true positive (TP)/(TP + false negative (FN)). The specificity was calculated as true negative (TN)/(TN + false positive (FP)). The accuracy was calculated as (TN + TP)/(TN + TP + FN + FP). Calculation of 95 % confidence intervals was done by the Exact (Clopper-Pearson) method. All analyses were performed with IBM SPSS v24 (IBM Corp, Armonk, NY, USA). All p-values were two-tailed, and $p < 0.05$ was considered statistically significant.

3. Results

3.1. Participant population

Four hundred ninety-eight participants (447 evaluable) were enrolled in the study between June 03 and October 29, 2021. The participant categories are shown in Fig. 1. The 447 evaluable participants (62 vaccinated and 385 unvaccinated) were distributed across (1) nine clinical centers in the UK and Spain consisting of 219 participants (25 vaccinated) and (2) six clinical centers in the US consisting of 228 participants (37 vaccinated). Among the unvaccinated participants, 220 participants were positive by the reference assay, 108 participants with a PCR-confirmed infection reported symptoms onset >21 days ago and 77 participants had experienced an asymptomatic infection.

The participant categories are illustrated in Fig. 1. The demographics for the evaluable participants are shown in Table 1, and the medical history in Table 2.

PSO: Post-symptom onset.

4. Unvaccinated cohort

The test results of the Panbio™ test for the unvaccinated cohort, interpreted at 20 min, are shown in Table 3. The results are stratified by symptom status, by PCR confirmation of SARS-CoV-2 infection, and by days post-symptom onset. For participants with PCR-confirmed SARS-CoV-2 infection who reported COVID-19 symptom onset >21 days ago, the fingerstick capillary whole blood sensitivity was 92.6 % (95 % CI: 85.9, 96.7), increasing to 96.7 % (88.5, 99.6) for those with PCR-confirmed infection and symptom onset 22–180 days ago. The sensitivity among asymptomatic participants was 80.5 % (69.9, 88.7). The fingerstick capillary whole blood specificity was 97.0 % (93.1, 99.0). Five samples were Panbio™ positive/Alinity™ negative; one of these was positive with the Roche Elecsys S anti-SARS-CoV-2 (Elecsys®) assay. For venous plasma, the sensitivity was 87.0 % (79.2, 92.7) for participants with PCR-confirmed SARS-CoV-2 infection and symptom onset >21 days ago, increasing to 90.0 % (79.5, 9.26) for participants with PCR-confirmed infection who reported symptom onset 22–180 days ago. The sensitivity for asymptomatic participants was 83.1 % (72.9, 90.7). The plasma specificity for unvaccinated participants was 96.3 % (92.2, 98.6). Six samples were positive by the Panbio™ test and negative by the Alinity™ test. Five of these six samples had sufficient residual volume for additional testing; one of the five was Elecsys® positive.

Whole blood: The 5 Panbio™ positive/Alinity™ negative samples were investigated with additional testing on the Elecsys® assay

Table 1
Participant demographics all evaluable participants.

Stat		Overall (N = 447)	Alinity™ Positive (N = 281)	Alinity™ Negative (N = 166)
Age	Mean (SD)	36 (14.2)	38 (14.6)	34 (13.4)
	Median	33	36	32
	Range (Min-Max)	16–74	16–74	16–73
Gender	Male	299 (66.9 %)	194 (69.0 %)	105 (63.3 %)
	Female	148 (33.1 %)	87 (31.0 %)	61 (36.7 %)
Race	White	318 (71.1 %)	197 (70.1 %)	121 (72.9 %)
	Black	73 (16.3 %)	47 (16.7 %)	26 (15.7 %)
	Asian	23 (5.1 %)	13 (4.6 %)	10 (6.0 %)
	Mixed	17 (3.8 %)	11 (3.9 %)	6 (3.6 %)
	Other	8 (1.8 %)	7 (2.5 %)	1 (0.6 %)
	No Answer[a]	8 (1.8 %)	6 (2.1 %)	2 (1.2 %)

[a] "No Answer" was a response option for the race category question, for participants who did not want to disclose this information.

Table 2
Medical history[a] all evaluable participants.

Statistic	Response (N/Y)	All (N = 447)	Alinity™ (POS) (N = 281)	Alinity™ (NEG) (N = 166)
COVID-19 via test	N	297 (66.4 %)	138 (49.1 %)	159 (95.8 %)
	Y	150 (33.6 %)	143 (50.9 %)	7 (4.2 %)
Exposure to COVID-19	N	258 (57.7 %)	133 (47.3 %)	125 (75.3 %)
	Y	189 (42.3 %)	148 (52.7 %)	41 (24.7 %)
Symptom	N	259 (57.9 %)	122 (43.4 %)	137 (82.5 %)
	Y	188 (42.1 %)	159 (56.6 %)	29 (17.5 %)
Days between Panbio test and symptom onset	N/A	187	158	29
Mean (SD)		167.5 (140.3)	165.1 (131.5)	180.8 (183.5)
Median		167.0	168.0	141.0
Min-Max		0.0, 549	0.0, 549	4.0, 538
Hospital if symptom = "Y"	N	176 (39.4 %)	148 (52.7 %)	28 (16.9 %)
	Y	13 (2.9 %)	12 (4.3 %)	1 (0.6 %)
ICU if hospital = "Y"	N	9 (2.0 %)	8 (2.8 %)	1 (0.6 %)
	Y	5 (1.1 %)	5 (1.8 %)	
Ventilation if hospital = "Y"	N	12 (2.7 %)	11 (3.9 %)	1 (0.6 %)
	Y	2 (0.4 %)	2 (0.7 %)	
Vaccine	N	385 (86.1 %)	220 (78.3 %)	165 (99.4 %)
	Y	62 (13.9 %)	61 (21.7 %)	1 (0.6 %)
Days between Panbio test and the vaccine	N/A	62	61	1
Mean (SD)		94.1 (45.2)	91.7 (41.6)	236.0 (.)
Median		87.5	87.0	236.0
Min-Max		32, 237	32, 237	236, 236
Vaccine type	N/A	N/A	N/A	N/A
Pfizer		46 (10.3 %)	45 (16.0 %)	1 (0.6 %)
Moderna		8 (1.8 %)	8 (2.8 %)	N/A
Oxford		7 (1.6 %)	7 (2.5 %)	N/A
Novavax		1 (0.2 %)	1 (0.4 %)	N/A
Aches and pains	N	342 (76.5 %)	188 (66.9 %)	154 (92.8 %)
	Y	105 (23.5 %)	93 (33.1 %)	12 (7.2 %)
Conjunctivitis	N	441 (98.7 %)	276 (98.2 %)	165 (99.4 %)
	Y	6 (1.3 %)	5 (1.8 %)	1 (0.6 %)
Diarrhea (loose, watery stools three or more times a day)	N	411 (91.9 %)	250 (89.0 %)	161 (97.0 %)
	Y	36 (8.1 %)	31 (11.0 %)	5 (3.0 %)
Dry cough	N	333 (74.5 %)	186 (66.2 %)	147 (88.6 %)
	Y	114 (25.5 %)	95 (33.8 %)	19 (11.4 %)
Fever (measured temperature ≥38 °C)	N	345 (77.2 %)	194 (69.0 %)	151 (91.0 %)
	Y	102 (22.8 %)	87 (31.0 %)	15 (9.0 %)
Headache	N	328 (73.4 %)	175 (62.3 %)	153 (92.2 %)
	Y	119 (26.6 %)	106 (37.7 %)	13 (7.8 %)
Loss of speech or movement	N	440 (98.4 %)	275 (97.9 %)	165 (99.4 %)
	Y	7 (1.6 %)	6 (2.1 %)	1 (0.6 %)
Loss of taste or smell	N	336 (75.2 %)	180 (64.1 %)	156 (94.0 %)
	Y	111 (24.8 %)	101 (35.9 %)	10 (6.0 %)
Rash on skin	N	442 (98.9 %)	276 (98.2 %)	166 (100.0 %)
	Y	5 (1.1 %)	5 (1.8 %)	N/A
Runny or stuffy nose	N	379 (84.8 %)	222 (79.0 %)	157 (94.6 %)
	Y	68 (15.2 %)	59 (21.0 %)	9 (5.4 %)
Shortness of breath	N	383 (85.7 %)	223 (79.4 %)	160 (96.4 %)
	Y	64 (14.3 %)	58 (20.6 %)	6 (3.6 %)
Sore throat	N	374 (83.7 %)	222 (79.0 %)	152 (91.6 %)
	Y	73 (16.3 %)	59 (21.0 %)	14 (8.4 %)
Tiredness	N	313 (70.0 %)	163 (58.0 %)	150 (90.4 %)
	Y	134 (30.0 %)	118 (42.0 %)	16 (9.6 %)
Other	N	413 (92.4 %)	253 (90.0 %)	160 (96.4 %)
	Y	34 (7.6 %)	28 (10.0 %)	6 (3.6 %)

[a] Based on clinical standard of care diagnoses.

(1 of 5 was Elecsys® positive). The 5 Panbio™ positive/Alinity™ negative samples were also investigated with additional testing on two commercially available lateral flow tests (3 of 5 were positive on one of the two lateral flow tests).

Plasma: 5 of the 6 Panbio™ positive/Alinity™ negative samples were investigated with additional testing on the Elecsys® assay (1 of 5 was Elecsys® positive). These 5 Panbio™ positive/Alinity™ negative samples were also investigated with additional testing on two commercially available lateral flow tests (2 of 5 were positive on one of the two lateral flow tests). For one Panbio™ positive/Alinity™ negative sample, no further sample was available for any discrepant result resolution.

Table 3
Sensitivity and Specificity of the Professional Use Fingerstick Test (Panbio™ test) vs. Alinity™ (Unvaccinated Cohort) by PSO (Post-Symptom Onset) and PCR status All Evaluable Participants in the Unvaccinated Cohort.

	TP	FN	TN	FP	Total	% Sens (95 % CI)	% Spec (95 % CI)
Fingerstick capillary whole blood							
All participants	193	27	160	5	385	87.7 (82.6, 91.8)	97.0 (93.1, 99.0)
>21 days PSO	124	11				91.9 (85.9, 95.9)	
>21 days PSO and PCR=POS	100	8				92.6 (85.9, 96.7)	
22–180 days PSO	65	3				95.6 (87.6, 99.1)	
22–180 days PSO and PCR=POS	58	2				96.7 (88.5, 99.6)	
Asymptomatic	62	15				80.5 (69.9, 88.7)	
Venous Plasma							
All participants	186	34	158	6	384	84.5 (79.1, 89.1)	96.3 (92.2, 98.6)
>21 days PSO	115	20			348	85.2 (78.1, 90.7))	
>21 days PSO and PCR=POS	94	14			348	87.0 (79.2, 92.7)	
22–180 days PSO	61	7			348	89.7 (79.9, 95.8)	
22–180 days PSO and PCR=POS	54	6			347	90.0 (79.5, 96.2)	
Asymptomatic	64	3			347	83.1 (72.9, 90.7))	

TP = True Positive; FN = False Negative; TN = True Negative; FP = False Positive.

5. Vaccinated cohort

For the vaccinated cohort, the test results of the Panbio™ test with fingerstick capillary whole blood and venous plasma samples are shown in Table 4. For fingerstick capillary whole blood, the sensitivity was 98.4 % (95 % CI: 91.2, 100.0) and the specificity was 100 % (2.5, 100.0) based on a single reference negative participant. For venous plasma, the overall sensitivity was 96.7 % (88.7, 99.6). The specificity was 100 % (2.5, 100.0).

5.1. Matrix equivalence between fingerstick capillary whole blood and venous plasma for the professional use test

The test results of the Panbio™ test obtained with fingerstick capillary whole blood, in comparison with the Panbio™ test results obtained with venous plasma, are shown in Table 5 (all evaluable participants). For this analysis, 450 participants were evaluable, including four participants that were unevaluable for the primary endpoint due to enrollment less than 30 days post vaccination or missing vaccination date. The positive agreement between fingerstick capillary whole blood and venous plasma was 95.7 % (95 % CI; 92.4, 97.8), the negative agreement was 90.8 % (85.9, 94.5) and the total agreement was 93.6 % (90.9, 95.6).

6. Discussion

This prospective, multi-center study enrolled participants from a general population of SARS-CoV-2 vaccinated and unvaccinated individuals, with and without prior COVID-19 symptoms, including those with prior mild COVID-19 symptoms. For the unvaccinated group, the Panbio™ test sensitivity for fingerstick capillary whole blood was 92.6 % (95 % CI; 85.9, 96.7) for those who had experienced a PCR-confirmed SARS-COV-2 infection with symptoms onset >21 days ago, increasing to 96.7 % (88.5, 99.6) with symptoms onset 22–180 days ago. The corresponding sensitivities for plasma were 87.0 % (79.2, 92.7) and 90.0 % (79.5, 96.2). The time interval of 21 days post symptoms onset was chosen based on the EU requirements; the Common Specifications for certain class D *in vitro* diagnostic medical devices under Regulation (EU) 2017/746, of July 4, 2022, require a COVID-19 antibody test sensitivity of ≥90 % in those with PCR-confirmed infection and symptoms onset >21 days ago [11]. The sensitivities for asymptomatic participants were 80.5 % (69.9, 88.7) for fingerstick whole blood and 83.1 % (72.9, 90.7) for plasma. For the vaccinated study participants, the Panbio™ sensitivity was 98.4 % (91.2, 100.0) for fingerstick whole blood and 96.7 % for plasma. The specificity of Panbio™ among unvaccinated participants was 97.0 % (93.1, 99.0) for fingerstick whole blood. The overall Panbio™ matrix equivalence between fingerstick whole blood and plasma was 93.6 % (90.9, 95.6).

Lower SARS-CoV-2 peak antibody titers and more rapid conversion to antibody-negative status have been reported for individuals with a past asymptomatic or mild infection, compared to individuals with a past moderate or severe infection [14,15]. Here, a lower Panbio™ sensitivity was observed among unvaccinated participants with a past asymptomatic infection compared to those with past symptoms. Based on the lower Panbio™ sensitivity in asymptomatic individuals, the Negative Predictive Value (NPV) will be lower in

Table 4
Sensitivity and Specificity of the Panbio™ vs Alinity™ (Vaccinated Cohort) All Evaluable Participants in the Vaccinated Cohort.

	TP	FN	TN	FP	Total	% Sens (95 % CI)	% Spec (95 % CI)
Fingerstick capillary whole blood							
All participants	60	1	1	0	62	98.4 (91.2, 100.0))	100.0 (2.5, 100.0)
Venous Plasma							
All participants	59	2	1	0	62	96.7 (88.7, 99.6))	100.0 (2.5, 100.0)

TP = True Positive; FN = False Negative; TN = True Negative; FP = False Positive.

Table 5
Matrix Equivalence between Fingerstick Capillary Whole Blood and Venous Plasma in Professional Use in all evaluable participants. All participants.

		Panbio™ venous plasma	
		POS	NEG
Panbio™ fingerstick capillary whole blood	**POS**	243	18
	NEG	11	178
		Positive Agreement: 95.7 % (95 % CI: 92.4, 97.8)	Negative Agreement: 90.8 % (95 % CI: 85.9, 94.5)
		Total Agreement: 93.6 % (95 % CI: 90.9, 95.6)	
Unvaccinated participants			
		Panbio™ venous plasma	
		POS	NEG
Panbio™ fingerstick capillary whole blood	**POS**	181	17
	NEG	11	175
		Positive Agreement: 94.3 % (95 % CI: 90.0, 97.1)	Negative Agreement: 91.1 % (95 % CI: 86.2, 94.8)
		Total Agreement: 92.7 % (95 % CI: 89.6, 95.1)	
Vaccinated participants			
		Panbio™ venous plasma	
		POS	NEG
Panbio™ fingerstick capillary whole blood	**POS**	62	1
	NEG	0	3
		Positive Agreement: 100.0 % (95 % CI: 94.2, 100.0)	Negative Agreement: 75.0 % (95 % CI: 19.4, 99.4)
		Total Agreement: 98.5 % (95 % CI: 91.8, 100.0)	

this group. Hence asymptomatic individuals may benefit from testing using a laboratory SARS-CoV-2 antibody test with higher sensitivity, or using PCR if the patient is within the appropriate disease time window for PCR testing. Some samples with very low levels of SARS-CoV-2 IgG had a positive reference result while the Panbio™ result was negative. This study also showed a greater Panbio™ sensitivity among the unvaccinated participants with a symptomatic infection during the past 180 days, in comparison with a symptomatic infection >180 days ago. SARS-CoV-2 IgG antibody levels decrease over time [6], which likely is one reason for the difference in sensitivity when stratifying participants by days since symptom onset.

In analytical studies, the Panbio™ test has been investigated by the manufacturer for potential cross-reactivity to individuals with other medical conditions, including Human Coronaviruses 229E, HKU1, NL63 and OC43, as well as Influenza A and B. As no cross-reactivity was observed, the specimens with a positive reference result are considered to be positive for antibodies to SARS-CoV-2. In addition, the study reference test has been similarly investigated for potential cross-reactivity and has also been reported to have a high specificity (>99.5 %).

Separately, an overall sensitivity of 97.0 % (95 % CI; 94.4, 98.6) for Panbio™ in frozen plasma and serum samples, a sensitivity of 96.8 % (94.0, 98.5) for those with a PCR confirmed infection and symptom onset >21 days ago, and a specificity of 99.0 % (97.5, 99.7) in pre-pandemic samples have been reported by the manufacturer of the Panbio™ test [16].

An evaluation was published in March 2022, consisting of 14 SARS-CoV-2 antibody point of care (POC) tests, of which 13 were lateral flow assays and one was a microfluidic immunofluorescence assay. The sensitivity was evaluated against a previous RT-PCR test result and pre-pandemic venous samples were used as control samples. The three most promising lateral flow tests showed sensitivities of 80.3–98.1 % during 20–79 days post-symptom onset, 81.4–93.2 % during 80–139 days post-symptom onset and 54.4–82.3 % for ≥140 days post-symptom onset. Paired serum and fingerstick capillary blood samples were evaluated for 6 lateral flow assays and the microfluidic immunofluorescence assay. These results showed a decrease in sensitivity, with sensitivities of 9.1 %–71.1 % for the lateral flow assays interpreted by the healthcare worker [17].

In this study, the Panbio™ tests were performed in hospital rooms/clinics, by non-laboratory trained staff, who received no training other than the product *Instructions for Use* and the *Quick Reference Guide*. Based on usability questionnaire responses from 234 healthcare workers without formal laboratory training, the test was rated as "very easy to conduct" or "fairly easy to conduct" by 97.4 % of users.

The primary care diagnostic process depends on accurate, reliable, and reproducible laboratory testing [18]. For certain diseases, diagnostic tests that can be performed quickly and easily, and provide fast results, are expected by patients and are being increasingly used by healthcare providers [19]. These POC or rapid diagnostic tests that have the necessary sensitivity and specificity are essential for effective treatment, and play a critical role in preventing further transmission of infectious diseases [20]. SARS-CoV-2 antibodies provide a critical tool for monitoring patient recovery, protection from re-infection, and potential long-term effects of a SARS-CoV-2 infection. SARS-CoV-2 antibody tests can also play a critical role in serosurveillance to determine the spread of the pandemic and as a complement to RT-PCR testing for patient management [21]. The sensitivity obtained with fingerstick whole blood, especially for those with a past symptomatic infection and for vaccinated individuals, the rapid turn-around time and the ease of use, support the use of Panbio™ test as a POC test outside hospital settings, including in cohorts that may otherwise be hard to reach, as well as for population surveillance of SARS-CoV-2 antibody status.

The study participants were enrolled between 3rd June and 29th October 2021, a period with world-wide dominance of the SARS

CoV-2 Delta variant. The analytical sensitivity of the Panbio™ test is traceable to the WHO International Standard (NIBSC code 20/136, December 2020) and the WHO International Reference Panel for anti-SARS-COV-2 antibodies (NIBSC code 20/268, December 2020) [16]. However, the test has maintained a high sensitivity in spite of the variant evolution. Continuous Panbio™ testing using antibodies to emerging SARS-CoV-2 variants, including BA.1/2 and BA.4/5 has ensured that the evolution of new variants has not affected the performance of the Panbio™ COVID-19 IgG Rapid Test Device [22,23]. Furthermore, this has allowed the test device to be quickly adapted to new emerging variants.

Limitations of the study include a relatively low number vaccinated participants evaluable for the primary endpoint (N = 62); nevertheless, the test showed strong performance in this cohort. Other limitations include lack of PCR confirmation and hence infection timepoint for those who had experienced an asymptomatic SARS-CoV-2 infection, as well as absence of past infection variant data. In addition, analyses of Panbio™ performance using venous whole blood and serum were not included in this prospective study.

The presence of SARS-CoV-2 IgG cannot be inferred to represent protective immunity against SARS-CoV-2 reinfection. Future research should include investigation as to whether the presence of antibodies are markers of protection.

Additional knowledge gaps include: the duration of detectable IgG; relationship of seropositivity to shedding of infectious virus in the convalescent phase; effect of seropositivity on COVID-19 vaccine response and factors that affect antibody responses.

7. Conclusion

In this prospective, multi-center study, the Panbio™ tests were performed in hospital rooms and at the clinics and were easy and well accepted by non-laboratory trained staff. This test can help identify patients who were previously SARS-CoV-2 infected and patients with prior vaccination. Choosing a test with high specificity is especially important to reduce false positive results.

In conclusion, the sensitivity, specificity and accuracy of the Panbio™ test from fingerstick capillary whole blood were high. Testing between 22 and 180 days post-symptom onset maximizes the sensitivity and specificity to detect past infection or vaccination.

Data availability

Sharing research data helps other researchers evaluate your findings, build on your work and to increase trust in your article. We encourage all our authors to make as much of their data publicly available as reasonably possible. Please note that your response to the following questions regarding the public data availability and the reasons for potentially not making data available will be available alongside your article upon publication.

Has data associated with your study been deposited into a publicly available repository? No.

Ethics committee statement

The study CLDG-0502 was reviewed by a central Ethics Committee, the Yorkshire & The Humber -Bradford Leeds Research Ethics Committee, in the UK and was also reviewed by an ethics committee in Spain (Comité de Ética de la Investigación con Medicamentos Hospital General Universitario Gregorio Marañó).

In the US, the study CLDG-0511 was reviewed by a central IRB – Advarra IRB, 6100 Merriweather Dr., Suite 600, Columbia, MD 21044. These studies were not commenced until all applicable written IRB/EC approvals were obtained in accordance with ICH, federal, state, local and institutional regulations.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Roy Vijesurier, Camilla Forssten, Simon Kordowich, Yin Li and Wenchi Lin report financial support was provided by Abbott Laboratories. Pablo Ryan and Patrick T. Kennedy report financial support was provided by Abbott Laboratories. Roy Vijesurier, Camilla Forssten, Simon Kordowich, Yin Li and Wenchi Lin report a relationship with Abbott Laboratories that includes: employment. Pablo Ryan and Patrick T. Kennedy report a relationship with Abbott Laboratories that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

This study was funded by Abbott. We wish to express our sincere gratitude to the participants who generously contributed their time and resources to partake in this study. Additionally, we would like to extend our thanks to all the researchers from the participating institutions who played a crucial role in the success of this research endeavour.

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