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Research Article

Evaluation of Diagnostic Accuracy of Rapid SARS-CoV-2 Antigen Detection Kits Used in Public Testing Centers in Mongolia

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Abstract

There is limited information on the performance of rapid antigen detection kits used in Mongolia to detect COVID-19 infection. In this study, we evaluated twenty-two rapid SARS-CoV-2 antigen detection kits used in the COVID-19 testing centers and in the laboratory of the National Center for Communicable Diseases in Mongolia by using sample dilution method. We found that the sensitivity was ≥90% in 9 kits, ≥80% in 11 kits, and ≤70% in 9 kits according to the detection limit for the kits (Ct value ≤25), while the sensitivity was ≥80% in 7 kits and ≤79% in the others based on the total number of tests. Our study suggests the basic recommendation for selecting rapid antigen detection kits for COVID-19 infection in our country.

Keywords: COVID-19; Antigen; Rapid test; RT-PCR; CT value

Introduction

The Coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan city, China in December 2019 [1]. Early diagnosis of COVID-19 infection is important for detecting the close contacts, reducing the transmission, and preventing from severe illness by starting treatment early. The nucleic acid amplification test (NAAT) -based assays such as real-time polymerase chain reaction (RT-PCR) is considered

as the golden standard to detect the COVID-19 infection [2, 3]. However, RT-PCR is a costly and timely method that requires trained personnel and laboratory environment. The Rapid SARS-CoV-2 antigen detection test allows us to detect the virus within 30 minutes without requiring laboratory environment and trained personnel [4]. However, sensitivity of rapid antigen test for SARS-CoV-2 is lower than the RT-PCR [5]. The different types of rapid antigen detection kits were developed, and its performance is variable depending on many factors. Therefore, the World Health Organization recommends that a rapid antigen test kit needs to meet a minimum performance requirement of at least 80% sensitivity and 97% specificity compared with a NAAT reference assay to be used [2]. The first case of COVID-19 was reported in Mongolia on March 10, 2020. According to the statistics, there have been 181646 COVID-19 cases reported in Mongolia by August 9, 2021 [6] and rapid SARS-CoV-2 antigen detection tests have been performed in the entrance of each province, countryside, family medicine hospitals, and pharmacies. Therefore, the evaluation on sensitivity and specificity of these rapid antigen detection kits used in Mongolia needs to be conducted to provide healthcare workers with valuable information.

Materials and methods

We conducted a prospective, multi-center, point of care evaluation of twenty-two rapid antigen detection kits in comparison to RT-PCR on nasopharyngeal swabs. Human samples were collected by following protocols approved by the Research Ethics Review Committee of the National Center for Communicable Diseases of Mongolia. Signed informed consent was obtained from all participants.

Sample collection

Twenty-two rapid SARS-CoV-2 antigen detection kits used in the following 5 public testing centers in 3 districts of Ulaanbaatar from January 7, 2021, to August 9, 2021. These testing centers include family medicine hospital in 26-r khoroo and #147 kindergarten in Bayanzurkh district; #143 kindergarten in Sukhbaatar district; Nomin plaza center in Songinokhairkhan district; and a testing center at the National Center for Communicable Diseases of Mongolia.

Two nasopharyngeal swabs were collected from each person with suspected symptoms for COVID19 infection at the above-mentioned testing centers by trained health care professionals: One for rapid antigen test and one for RT-PCR. Specimens for RT-PCR were collected in UTM (Universal Transport Medium). Thirty-one to fifty-four samples were collected for each kit and 810 samples were collected in total.

RT-PCR

Viral RNA was extracted from the 810 nasopharyngeal swab using ExiPrep™ 96 Viral DNA/RNA kit and EP96L-BXD035 fully automated machine. RT-PCR was performed using SARS-CoV-2 viral E gene (Roche, Berlin, Germany), internal control EAV (LightMix® SarbecoV E-gene plus EAV) multiplex primer/probe and Applied Biosystems AgPath-ID™ One-Step RT-PCR (Thermo Fisher Scientific) according to the previously described protocol at the reference laboratory of the National Center for Communicable Diseases of Mongolia.

Rapid Antigen Detection Test

A total of 22 rapid antigen detection kits including twenty-one for nasopharyngeal swabs (SD BioSensor "STANDART Q covid-19 Ag", Coretests "Covid-19 Ag test", JD Biotech "Sars-Cov-2 (Covid-19) antigen Rapid test", CTK Biotech "Onsite Covid-19 Ag Rapid Test", GCMS "Genedia W Covid-19 Ag", Safecare BIO-TECH "One step rapid test", Genbody "COVID-19Ag Detection of SARS-Cov-2 antigen",Sansure Biotech "Sars-Cov-2 rapid antigen test", Genesis "Kailibi Covid-19 Antigen",Wantai "SARS-Cov-2 Ag rapid test (Colloidal Gold)",PCL "PCL Covid-19 Ag Gold", Watmind "SARS-Cov-2 Diagnostic test kit", Won-med "Won-Med Covid-19 Ag test", Healgen "Coronavirus Ag rapid test", Lifotronic "Sars-Cov-2 Antigen", Sugentech "SGTi-Flex Covid-19 Ag", Lepu medical "Sars-Cov-2 Antigenrapid test, Abbot "Panbio Covid-19 Ag Rapid test device", GP-Getein biotech" One step Test for Sars-Cov-2 Antigen, Rapigen "Biocredit Covod-19 Ag One step rapid test") and one for saliva specimen (Coretests "COVID-19 Saliva Ag test") were used to detect the SARS-CoV-2. Coretests "COVID-19 Saliva Ag test" was used to detect COVID-19 infection for kids at the above-mentioned testing centers. Thirty-one to fifty-four samples were tested with each rapid antigen detection kit to detect COVID-19 by medical professionals at the above-mentioned testing centers according to the manufacturer's instruction of each kit. The results were reported as positive or negative. Two to three professionals independently interpreted the results of rapid antigen tests. Then, the samples were verified by RT-PCR at the Department of Virology of the National Center for Communicable Diseases of Mongolia.

Determination of the detection limits based on the Ct value

The high titer COVID-19 viral stock was prepared by collecting nasopharyngeal swabs from twenty COVID-19 positive patients who stayed at the National Center for Communicable Diseases for 1 to 2 in 4 mL UTM and serial dilution was done. Each diluted sample was tested by RT-PCR and CT value was determined. 28 samples with CT value of 15 to 35 were tested

with SD BioSensor "STANDART Q covid-19 Ag" rapid antigen detection kit. According to the WHO guidance for detecting COVID-19 virus using rapid antigen detection test (possible limit for detecting virus is Ct value ≤25 or >10^6 genomic virus copies/mL) approved on September 11, 2022 was used as a reference [7]. Fifteen samples with 15-27 Ct value were chosen and tested by diluting the samples with lysis buffer of each kit.

Methods for determining sensitivity and specificity of the rapid antigen detection kits

The following 2x2 table was used to determine the specificity and sensitivity of the rapid tests. Sensitivity=(A/A+C)*100; Specificity=D/(D+B)*100; Negative predictive value=D/(D+C)*100; Positive predictive value=A/(A+B)*100

A-Positive; B-False positive; C-False negative; D-negative

Statistical analysis

Sensitivity and specificity of each rapid antigen detection kit compared to results from SARS-CoV-2 specific RT-PCR were assessed, including overall accuracy and 95% confidence intervals (CI). P<0.05 is considered as statistically significant.

Results

Sensitivity and specificity of rapid antigen detection kits

Twenty-two rapid SARS-CoV-2 antigen detection kits were used in our study. 21 of all the rapid antigen detection kits were for detecting virus in nasopharyngeal swab and one was for detecting virus in saliva. Twenty-two rapid SARS-CoV-2 antigen detection kits were used to detect COVID-19 virus in 810 samples. Two to three professionals independently interpreted the results of rapid antigen tests by confirming negative or positive. The interpretation of the results by those professionals were same. Out of 810 samples, 135(16.7%) were positive; 662(81.7%) were negative; and 10 (1.2%) were false positive by rapid antigen detection test, respectively. 3(0.4%) of them were not qualified for the viral detection. However, 216 (26.7%) of total samples were RT-PCR positive whereas 594(73.3%) were negative. Seven rapid antigen detection kits showed the greater than 80% detection limit whereas fifteen rapid antigen detection kits showed less than 80% detection rate as compared to the results of RT-PCR (Table 1). In our study, 33 participants were tested with Coretests "COVID-19 Saliva Ag test" and 0 of them were positive while 8(24.2%) were confirmed with RT-PCR. It indicated that SARS-CoV-2 viral load in the saliva was not stable as compared to the viral load in the nasopharyngeal swab.

#	Names of the rapid antigen detection kit	Rapid antigen detection kit: N (%)				RT-PCR: N (%)		Total	Detection rate (%)
		Positive	False positive	Negative	Failed	Positive	Negative		
1	SD BioSensor "STANDART Q covid-19 Ag"	11(20.4)	0	43(79.6)	0	16(29.6)	38(70.4)	54	68.70%
2	Coretests "Covid-19 Ag test"	7(22)	3(9.4)	21(65.6)	1(3)	10(31.2)	22(68.8)	32	70.00%
3	JD Biotech "Sars-Cov-2 (Covid-19) antigen Rapid test"	8(18.2)	0	36(81.8)	0	11(25)	33(75)	44	72.70%
4	CTK Biotech "Onsite Covid-19 Ag Rapid Test"	6(14.3)	1(2.4)	34(80.9)	1(2.4)	7(16.7)	35(83.3)	42	85.70%
5	GCMS "Genedia W Covid-19 Ag"	2(5.7)	0	33(84.3)	0	7(20)	28(80)	35	28.60%
6	Safecare BIO-TECH "One step rapid test"	8(25.8)	1(3.2)	22(71)	0	10(32.3)	21(67.7)	31	80.00%
7	Genbody "COVID-19Ag Detection of SARS-Cov-2 antigen"	7(21.9)	2(6.3)	23(71.8)	0	10(31.2)	22(68.8)	32	70.00%
8	Sansure Biotech "Sars-Cov-2 rapid antigen test"	4(9.5)	0	38(80.5)	0	8(19.5)	34(80.5)	42	50.00%

9	Genesis "Kailibi Covid-19 Antigen"	9(29)	0	22(71)	0	11(35.5)	20(64.5)	31	81.80%
10	Wantai "SARS-Cov-2 Ag rapid test (Colloidal Gold)"	4(8.7)	0	42(92.3)	0	10(21.7)	36(78.3)	46	40.00%
11	PCL "PCL Covid-19 Ag Gold"	5(14.3)	0	30(85.7)	0	9(25.7)	26(74.3)	35	55.60%
12	Watmind "SARS-Cov-2 Diagnostic test kit"	6(14)	0	37(86)	0	8(18.6)	35(81.4)	43	75.00%
13	Won-med "Won-Med Covid-19 Ag test"	6(20)	0	24(80)	0	10(30)	20(70)	30	60.00%
14	Healgen "Coronavirus Ag rapid test"	9(25.7)	0	26(74.3)	0	11(31.4)	24(68.6)	35	81.80%
15	Lifotronic "Sars-Cov-2 Antigen"	8(24.2)	1(3)	24(72.8)	0	9(27.3)	24(72.7)	33	88.90%
16	Sugentech "SGTi-Flex Covid-19 Ag"	8(23.5)	2(6.3)	24(70.2)	0	9(26.5)	25(73.5)	34	88.90%
17	Lepu medical "Sars-Cov-2 Antigenrapid test (Colloidal immunochromatography)	2(5.9)	0	32(24.1)	0	11(32.4)	23(67.6)	34	18.20%
18	Coretests "COVID-19 Saliva Ag test"	0(0.0)	0	33(100)	0	8(24.2)	25(75.8)	33	0.00%
19	Anylab "Covid-19 Ag Test Kit"	5(11.4)	0	39(88.6)	0	9(20.5)	35(79.5)	44	55.60%
20	Abbot "Panbio Covid-19 Ag Rapid test device"	5(14.3)	0	30(85.7)	0	9(25.7)	26(74.3)	35	55.60%
21	GP-Getein biotech"One step Test for Sars-Cov-2 Antigen"	11(34.4)	0	21(64.6)	0	13(40.6)	19(59.4)	32	84.60%
22	Rapigen "Biocredit Covod-19 Ag One step rapid test"	4(12.1)	0	28(84.9)	1(3)	10(30.3)	23(69.7)	33	40.00%
Total		**135(16.7)**	**10(1.3)**	**662(81.7)**	**3(0.3)**	**216(26.7)**	**594(73.3)**	**810**	**62.50%**

Table 1: Performance of point of care testing for rapid SARS-CoV-2 antigen detection kits.

CT value-dependent specificity and sensitivity of rapid antigen detection kits

Viral load is presented as Ct values and the higher the Ct value, the lower the viral load is [8,9]. The high titer COVID-19 viral stock was prepared, and then serial dilution was done to determine the CT value-dependent detection limit for rapid antigen detection test. Ct value was identified at each dilution and 15 samples with Ct value of 15-27 were tested again by rapid antigen detection kits. One out of 22 rapid antigen detection kit detected virus in samples with Ct value ≤25; 11 of them detected virus in samples with Ct value ≤24; 6 of them detected virus in samples with Ct value ≤23; one of them detected virus in samples with Ct value ≤22; one of them detected virus in samples with Ct value ≤21, one of them detected virus in samples with Ct value ≤20, and one of them detected virus in samples with Ct value ≤18.5, respectively. Out of 22 rapid antigen detection kits, GCMS «Genedia W Covid-19 Ag» rapid antigen detection kit had the lowest detection limit and detected the virus at Ct≤18.5 whereas SD BioSensor «STANDART Q covid-19 Ag» rapid antigen detection kit had the highest detection limit and detected the virus at higher Ct value or Ct≤25 (Figure 1).

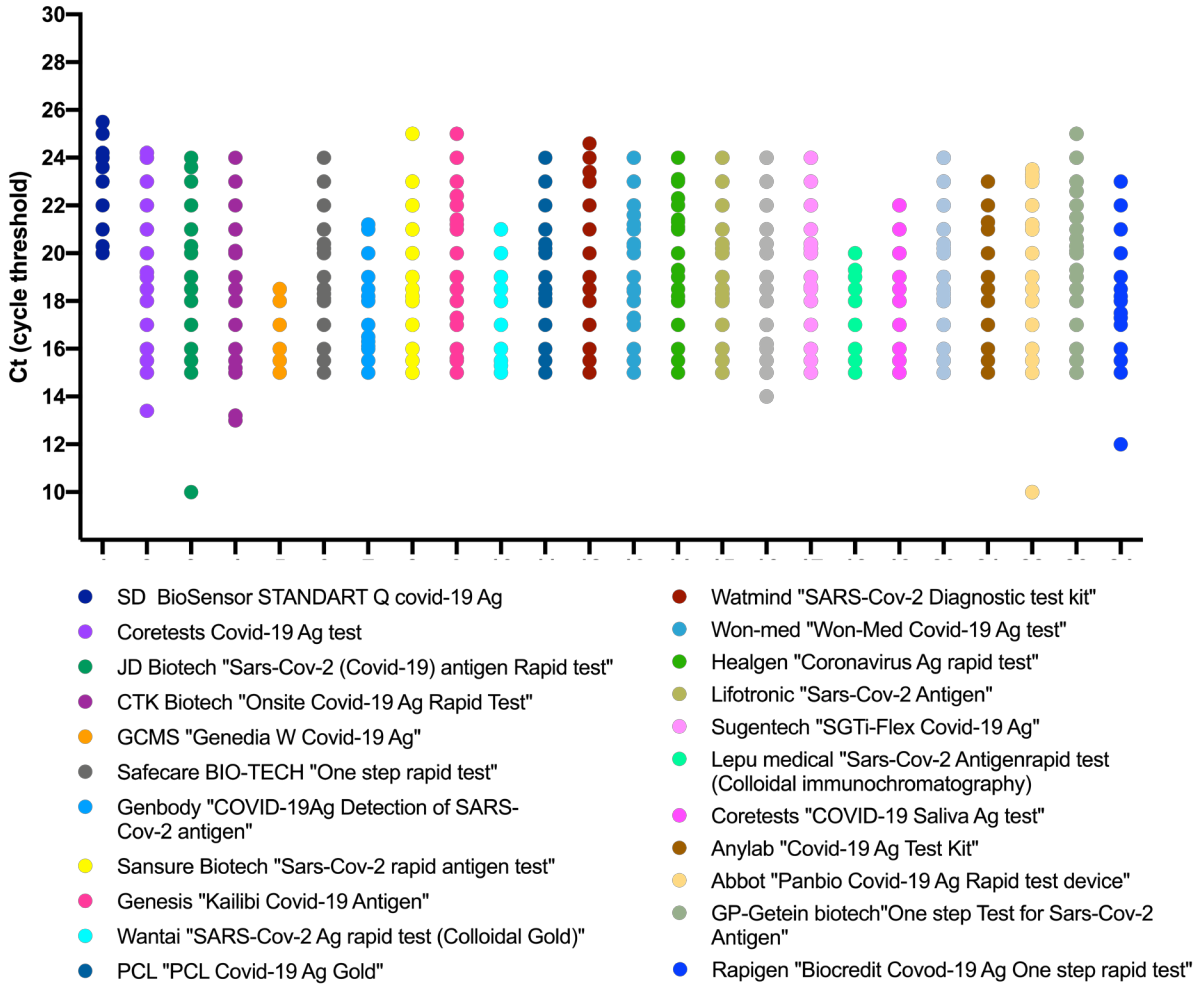

Figure 1: Ct value-dependent detection limit for rapid SARS-CoV-2 antigen detection kits.

Sensitivity, specificity, positive and negative predictive values of the rapid antigen tests are evaluated according to the above-mentioned method. There were 2 rapid antigen detection kits with greater than 90% sensitivity in samples with Ct value ≤25. There were 11 rapid antigen detection kits with greater than 80% sensitivity in samples with Ct value ≤25. There were 9 rapid antigen detection kits with more than 70% sensitivity in samples with Ct value ≤25. The higher sensitivity and specificity of these rapid antigen detection kits might be related to the limited number of specimens or symptoms of the patients. Overall, seven rapid antigen detection kits had more than 80% sensitivity while fifteen tests had less than 79% sensitivity (Table 2, Supplementary table.1). The saliva SARS-CoV-2 antigen detection kit showed 0% detection rate of SARS-CoV-2 virus at the testing centers, but at the laboratory, it detected the virus at Ct≤23.

#	Name of the rapid antigen detection kit	≤25				Total			
		Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV
1	SD BioSensor "STANDART Q covid-19 Ag"	91.7	100.0	100.0	97.7	68.8	100.0	100.0	88.4
2	Coretests "Covid-19 Ag test"	71.4	87.5	62.5	91.3	70.0	86.4	70.0	86.4
3	JD Biotech "Sars-Cov-2 (Covid-19) antigen Rapid test"	75.0	100.0	100.0	94.7	72.7	100.0	100.0	91.7
4	CTK Biotech "Onsite Covid-19 Ag Rapid Test"	83.3	97.1	83.3	97.1	85.7	97.1	85.7	97.1
5	GCMS "Genedia W Covid-19 Ag"	50.0	100.0	100.0	93.9	28.6	100.0	100.0	84.8
6	Safecare BIO-TECH "One step rapid test"	83.3	96.0	83.3	96.0	80.0	95.2	88.9	90.9
7	Genbody "COVID-19Ag Detection of SARS-Cov-2 antigen"	75.0	91.7	75.0	91.7	70.0	90.9	77.8	87.0
8	Sansure Biotech "Sars-Cov-2 rapid antigen test"	60.0	100.0	100.0	94.9	50.0	100.0	100.0	89.5
9	Genesis "Kailibi Covid-19 Antigen"	83.3	100.0	100.0	96.2	81.8	100.0	100.0	90.9
10	Wantai "SARS-Cov-2 Ag rapid test (Colloidal Gold)"	80.0	100.0	100.0	97.6	44.4	100.0	100.0	88.1
11	PCL "PCL Covid-19 Ag Gold"	80.0	100.0	100.0	96.8	55.6	100.0	100.0	86.7
12	Watmind "SARS-Cov-2 Diagnostic test kit"	83.3	100.0	100.0	97.4	75.0	100.0	100.0	94.6
13	Won-med "Won-Med Covid-19 Ag test"	85.7	100.0	100.0	95.8	60.0	100.0	100.0	83.3
14	Healgen "Coronavirus Ag rapid test"	87.5	100.0	100.0	96.4	81.8	100.0	100.0	92.3
15	Lifotronic "Sars-Cov-2 Antigen"	83.3	96.3	83.3	96.3	88.9	95.8	88.9	95.8

16	Sugentech "SGTi-Flex Covid-19 Ag"	83.3	92.9	71.4	96.3	88.9	92.0	80.0	95.8
17	Lepu medical "Sars-Cov-2 Antigenrapid test (Colloidal immunochromatography)	33.3	100.0	100.0	87.5	18.2	100.0	100.0	71.9
18	Coretests "COVID-19 Saliva Ag test"	0.0	100.0	0.0	78.8	0.0	100.0	0.0	75.8
19	Anylab "Covid-19 Ag Test Kit"	66.7	100.0	100.0	95.0	55.6	100.0	100.0	89.7
20	Abbot "Panbio Covid-19 Ag Rapid test device"	83.3	100.0	100.0	96.7	55.6	100.0	100.0	86.7
21	GP-Getein biotech"One step Test for Sars-Cov-2 Antigen"	90.0	100.0	100.0	95.7	84.6	100.0	100.0	90.5
22	Rapigen "Biocredit Covod-19 Ag One step rapid test"	66.7	100.0	100.0	92.9	40.0	100.0	100.0	78.6
PPV-positive predictive value; NPV-negative predictive value									

Table 2: Sensitivity, specificity, PPV and NPV of the rapid antigen detection kits.

#	Name of the rapid antigen detection kit	Ct value ≤25			Total		
		Sensitivity	95% CI	*P* value	Sensitivity	95% CI	*P* value
1	SD BioSensor "STANDART Q covid-19 Ag"	91.67%	75-100%	0.000001	68.75%	45-92%	0.00004
2	Coretests "Covid-19 Ag test"	71.43%	35-100%	0.0082	70.00%	40-99%	0.0013
3	JD Biotech "Sars-Cov-2 (Covid-19) antigen Rapid test"	75.00%	43-100%	0.0025	72.73%	45-100%	0.00042
4	CTK Biotech "Onsite Covid-19 Ag Rapid Test"	83.33%	51-100%	0.0041	85.71%	58-100%	0.00096
5	GCMS "Genedia W Covid-19 Ag"	50.00%	7-100%	0.18	28.57%	7-65%	0.17
6	Safecare BIO-TECH "One step rapid test"	83.33%	51-100%	0.0041	80.00%	54-100%	0.0002
7	Genbody "COVID-19Ag Detection of SARS-Cov-2 antigen"	75.00%	43-100%	0.0025	70.00%	40-99%	0.0013
8	Sansure Biotech "Sars-Cov-2 rapid antigen test"	60.00%	12-100%	0.07	50.00%	13-87%	0.033
9	Genesis "Kailibi Covid-19 Antigen"	83.33%	51-100%	0.0041	81.82%	58-100%	0.00005
10	Wantai "SARS-Cov-2 Ag rapid test (Colloidal Gold)"	66.67%	25-100%	0.025	40.00%	8-72%	0.00004
11	PCL "PCL Covid-19 Ag Gold"	80.00%	41-100%	0.016	55.56%	21-90%	0.00004
12	Watmind "SARS-Cov-2 Diagnostic test kit"	83.33%	51-100%	0.0041	75.00%	43-100%	0.0025
13	Won-med "Won-Med Covid-19 Ag test"	85.71%	58-100%	0.00096	60.00%	28-92%	0.0051
14	Healgen "Coronavirus Ag rapid test"	87.50%	63-100%	0.00021	81.82%	58-100%	0.00005
15	Lifotronic "Sars-Cov-2 Antigen"	83.33%	51-100%	0.0041	88.89%	67-100%	0.00004
16	Sugentech "SGTi-Flex Covid-19 Ag"	83.33%	51-100%	0.0041	88.89%	67-100%	0.00004

17	Lepu medical "Sars-Cov-2 Antigenrapid test (Colloidal immunochromatography)	33.33%	4-75%	0.17	18.18%	6-42%	0.16
18	Coretests "COVID-19 Saliva Ag test"	0.00	0		0.00	0	
19	Anylab "Covid-19 Ag Test Kit"	66.67%	25-100%	0.025	55.56%	21-90%	0.013
20	Abbot "Panbio Covid-19 Ag Rapid test device"	83.33%	51-100%	0.0041	55.56%	21-90%	0.013
21	GP-Getein biotech"One step Test for Sars-Cov-2 Antigen"	90.00%	70-100%	0.00001	84.62%	64-100%	0.000001
22	Rapigen "Biocredit Covod-19 Ag One step rapid test"	66.67%	25-100%	0.025	40.00%	8-72%	0.036

Supplementary Table 1: 95% CI and P value of sensitivity of rapid antigen detection kits.

Discussion

During this COVID-19 pandemic, diagnostic testing is an essential part to prevent the spreading of this virus and to manage the isolation and treatment. In the present study, we determined the performance characteristics of twenty-two rapid antigen detection kits for detecting SARS-CoV-2 virus used in Mongolia by comparing the results with RT-PCR using the sample dilution method. Our study showed that rapid antigen kits used in Mongolia had low sensitivity as compared to the RT-PCR. Therefore, negative result of rapid antigen detection kit cannot confirm the absence of COVID-19 infection and RT-PCR needs to be performed to confirm the COVID-19 infection.

In our study, Coretests "COVID-19 Saliva Ag test" showed 0% detection rate, suggesting that saliva has low viral load compared to the nasopharyngeal swab. Some previously published papers showed that the survival of SARS-CoV-2 virus in the saliva was low [10,11]. Overall sensitivity and specificity of the saliva antigen rapid test were 66.1% and 99.6% which increased to 88.6% with Ct ≤30 cutoff in 789 samples. Sensitivity of the rapid antigen detection kit for saliva among people with symptoms and without symptoms ranged from 69.2% to 50%, respectively [12]. Previous studies showed that sensitivity of the SARS-CoV-2 virus in the saliva of the kids was low or 53%-73% [13,14]. We used Coretests "COVID-19 Saliva Ag test" for kids with suspected COVID-19 infection in this study. Our results are consistent with the results of other published papers.

We found that sensitivity of SD BioSensor "STANDART Q covid-19 Ag" was the kit with higher detection limit with Ct value≤25 cutoff and sensitivity of 91.7%. There are lots of studies have been conducted to assess the sensitivity and specificity of SD BioSensor "STANDART Q covid-19 Ag" and other rapid antigen detection kits. Study conducted in Copenhagen, Denmark reported that SD Biosensor rapid antigen kit had a sensitivity of 48.5% and a specificity of 100% [15]. Previous studies also tested its sensitivity for symptomatic or asymptomatic participants. It reported that sensitivity of Biosensor rapid antigen detection kit was 59.4% for the asymptomatic participants while the sensitivity was increased to 73.3% for symptomatic participants [16]. If viral load cut-off was greater than 5.2 log (10) SARS-CoV-2 E-gene copies/mL, sensitivities were 89% for PanBio, and 88% for SD-Biosensor, respectively[16]. Begum MN et al. tested specificity and sensitivity of SD Biosensor kit and found that overall sensitivity was 78.0% and the specificity was 94.7% [17]. SD Biosensor kit showed more sensitivity (81.7%) for nasopharyngeal specimen compared with the nasal cavity (77.5%) [18]. When they tested sensitivity of the SD Biosensor kit on 110 nasopharyngeal samples, it was 86.7% [19]. In Slovakia, they conducted the study for determining sensitivity of the Biosensor kit among 991 samples from mostly asymptomatic individuals and found that very low sensitivity of 30.6% with higher specificity 98.8%. But its sensitivity was much better in symptomatic patients and samples with Ct < 25 [20]. Performance of the SD Biosensor was validated in specimens from 529 participants at the Geneva university hospital and sensitivity was 89.0% [21]. Eleonora Cottone et al evaluated the performance of SD Biosensor rapid antigen detection kit among patients admitted to the hospital in Roeselare, Belgium from November 1 to December 2, 2020. They found that its sensitivity was only 45% and increased to 67% if the samples were collected during 5 to 7 symptomatic days. In Madagascar, they tested 200 samples with both RT-PCR and SD Biosensor rapid antigen detection kit and sensitivity of the rapid antigen kit was 62.66% with 100% specificity while sensitivity was 100% in samples with Ct<29 [22].The sensitivity was 99% with Ct<25 cutoff and it decreased to 31% with the Ct>30 cutoff [23]. In Copenhagen, Denmark, sensitivity and specificity of the BioSensor standard Q Covid-19 test were 69.7% and 99.5%, respectively among people who visited at the public center [24]. Other rapid test also showed better sensitivity for symptomatic patients compared to the asymptomatic patients [25]. In Netherlands, Abbott and SD Biosensor showed the specificity of 97.30% for infected people [26]. The overall sensitivity of the rapid tests ranged from 65% to 79%, and the specificity was 100% for all of them. The sensitivity was higher for those samples with Ct value<25 and from patients presenting

within the first week of symptoms [27]. According to the study in Central Finland in November in 2020, sensitivity of Roche-SD Biosensor rapid antigen test was greater than 94% with >99% specificity for individuals with symptoms that lasted for 1 to 7 days [28]. Sensitivity of the STANDARD Q COVID-19 Ag test Korea was 94.94% and specificity was 100%. Sensitivity was higher for symptomatic patients as compared with asymptomatic patients. In contrast, this study reported that duration of symptoms did not affect the sensitivity of the test. Similarly, the sample with higher Ct value showed low sensitivity [29] and our results are consistent with previously conducted studies.

In this study, 35 participants were tested with Abbot "Panbio Covid-19 Ag Rapid test device" and 5(14.3%) were positive and 9(25.7%) were confirmed with RT-PCR. The PanbioTM Covid-19 Ag Rapid Test device (Abbott) was validated in 535 participants, with 106 positive Ag-RDT results out of 124 positive RT-PCR individuals, yielding a sensitivity of 85.5%. According to the previous Cochrane analysis, sensitivity of Abbot Panbio Covid-19 kit was 75.1% in symptomatic patients while 48.95% in asymptomatic patients with more than 98% specificity [30]. Researchers also reported that patients referred by treating physicians had higher sensitivity than the patients referred by other reasons. Moreover, they showed rapid antigen detection kit had higher sensitivity in people with comorbidities than without comorbidities [30]. Rapid SARS-CoV-2 antigen test tends to show false positive and negative results and it depends on the technical procedures for collecting samples as well [31].Thus, researchers suggested that the rapid antigen test should be used with proper techniques to get true results even though each SARS-CoV-2 rapid antigen test produces wide range of sensitivity and specificity [32,33].

In summary, this study presents the kits used in Mongolia have higher sensitivity and specificity at Ct<25 cutoff than the previously published studies in other countries even though its sensitivity was low as compared to the RT-PCR. It might be related to the samples that we collected had high viral load. The samples with high viral load (Ct value ≤25) accounted for 50% among all the samples tested from January 7, 2021, to August 9, 2021 for this study. However, some rapid SARS-CoV-2 antigen detection kits used in our country had low sensitivity and it detected the virus with Ct value≤23. When the number of COVID-19 infection is increased, the rapid antigen detection kit tended to show more false positive and negative results according to the previous study [34]. We found that some of the rapid antigen detection kits showed the different results for one sample and it may be associated with the changes of the viral load during the infection [35]. Although rapid antigen test is the relatively fast and reliable test for detecting COVID-19 infection if the viral load is high, if the samples have low viral load, possibility of diagnosing COVID-19 infection by rapid antigen kit is decreased and usage of antigen detection is limited.

This study suggests the basic recommendation for selection of rapid antigen detection kits for COVID-19 infection in Mongolia. However, the further evaluation for selection and performance of the rapid antigen kits for COVID-19 needs to be done by correlating its sensitivity with different factors to improve our health care service against COVID-19 infection.

Limitation of this study: Number of samples collected for each rapid antigen detection kit was not enough and the results and sensitivities varied between each rapid antigen detection kit depending on the possible technical errors during sample collection, symptomatic or asymptomatic patients, etc.

References

1. The-nCo VOJFEIT, Li Q (2020) An Outbreak of NCIP (2019-nCoV) Infection in China - Wuhan, Hubei Province, 2019-2020. China CDC Wkly 2:79-80.
2. WHO (2020) Antigen-detection in the diagnosis of SARS-CoV-2 infection using rapid immunoassays. Interim guidance.
3. Broberg E, Ciancio B, Ködmön C, et al., (2020) Options for the use of rapid antigen tests for COVID-19 in the EU/EEA and the UK.
4. Torres I, Poujois S, Albert E, Colomina J, Navarro D (2021) 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. Clin Microbiol Infect 27: 636.e1-636.e4.
5. Schuit E, Veldhuijzen IK, Venekamp RP, van den Bijllaardt W, Pas SD, et al., (2021) Diagnostic accuracy of rapid antigen tests in asymptomatic and presymptomatic close contacts of individuals with confirmed SARS-CoV-2 infection: cross sectional study. BMJ 374:n1676.
6. Worldmeter. Coronavirus Mongolia. In: Worldmeters.info; 2022.
7. WHO. Antigen-detection in the diagnosis of SARS-CoV-2 infection using rapid immunoassays 11 September 2020.
8. Sarkar B, Sinha RN, Sarkar K (2020) Initial Viral Load of a COVID-19-Infected Case Indicated by its Cycle Threshold Value of Polymerase Chain Reaction Could be used as a Predictor of its Transmissibility - An Experience from Gujarat, India. Indian J Community Med 45:278-282.
9. La Scola B, Le Bideau M, Andreani J, Hoang VT, Grimaldier C, et al., (2020) Viral RNA load as determined by cell culture as a management tool for discharge of SARS-CoV-2 patients from infectious disease wards. Eur J Clin Microbiol Infect Dis 39:1059-1061.
10. To KK, Tsang OT, Yip CC, Chan KH, Wu TC, et al., (2020) Consistent Detection of 2019 Novel Coronavirus in Saliva. Clin Infect Dis 71:841-843.
11. Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, et al., (2020) Virological assessment of hospitalized patients with COVID-2019. Nature 581:465-469.

12. Igloi Z, Velzing J, Huisman R, Geurtsvankessel C, Comvalius A, et al., (2021) Clinical evaluation of the SD Biosensor SARS-CoV-2 saliva antigen rapid test with symptomatic and asymptomatic, non-hospitalized patients. PLoS One 16:e0260894.

13. Chong CY, Kam KQ, Li J, Maiwald M, Loo LH, et al., (2021) Saliva is not a useful diagnostic specimen in children with Coronavirus Disease 2019. Clin Infect Dis 73:e3144-e3145.

14. Han MS, Seong MW, Kim N, Shin S, Cho SI, et al., (2020) Viral RNA Load in Mildly Symptomatic and Asymptomatic Children with COVID-19, Seoul, South Korea. Emerg Infect Dis 26: 2497-2499.

15. Jakobsen KK, Jensen JS, Todsen T, Kirkby N, Lippert F, et al., (2022) Accuracy of anterior nasal swab rapid antigen tests compared with RT-PCR for massive SARS-CoV-2 screening in low prevalence population. APMIS 130: 95-100.

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

17. Begum MN, Jubair M, Nahar K, Rahman S, Talha M, et al., (2022) Factors influencing the performance of rapid SARS-CoV-2 antigen tests under field condition. J Clin Lab Anal 36: e24203.

18. Lee S, Widyasari K, Yang HR, Jang J, Kang T, et al., (2022) Evaluation of the Diagnostic Accuracy of Nasal Cavity and Nasopharyngeal Swab Specimens for SARS-CoV-2 Detection via Rapid Antigen Test According to Specimen Collection Timing and Viral Load. Diagnostics (Basel) 12:710.

19. Orsi A, Pennati BM, Bruzzone B, Ricucci V, Ferone D, et al., (2021) On-field evaluation of a ultra-rapid fluorescence immunoassay as a frontline test for SARS-CoV-2 diagnostic. J Virol Methods 295: 114201.

20. Alghounaim M, Bastaki H, Bin Essa F, Motlagh H, Al-Sabah S (2021) The Performance of Two Rapid Antigen Tests During Population-Level Screening for SARS-CoV-2 Infection. Front Med (Lausanne) 8:797109.

21. Berger A, Nsoga MTN, Perez-Rodriguez FJ, Abi Aad Y, Sattonnet-Roche P, et al., (2021) Diagnostic accuracy of two commercial SARS-CoV-2 antigen-detecting rapid tests at the point of care in community-based testing centers. PLoS One 16:e0248921.

22. Randriamahazo TR, Andrianarivelo AM, Rakotoarivo AT, Raheritiana TM, Rakotovao LA, et al., (2022) Evaluation of antigen-based rapid detection test for the diagnosis of SARS CoV-2 in low-income countries. J Virol Methods 300:114409.

23. Jääskeläinen AE, Ahava MJ, Jokela P, Szirovicza L, Pohjala S, et al., (2021) Evaluation of three rapid lateral flow antigen detection tests for the diagnosis of SARS-CoV-2 infection. J Clin Virol 137:104785.

24. Jakobsen KK, Jensen JS, Todsen T, Tolsgaard MG, Kirkby N, et al., (2021) Accuracy and cost description of rapid antigen test compared with reverse transcriptase-polymerase chain reaction for SARS-CoV-2 detection. Dan Med J 68:A03210217.

25. Siddiqui ZK, Chaudhary M, Robinson ML, McCall AB, Peralta R, et al., (2021) Implementation and Accuracy of BinaxNOW Rapid Antigen COVID-19 Test in Asymptomatic and Symptomatic Populations in a High-Volume Self-Referred Testing Site. Microbiol Spectr 9:e0100821.

26. van Beek J, Igloi Z, Boelsums T, Fanoy E, Gotz H, et al., (2022) From more testing to smart testing: data-guided SARS-CoV-2 testing choices, the Netherlands, May to September 2020. Euro Surveill 27:2100702.

27. Navero-Castillejos J, Casals-Pascual C, Narváez S, Cuesta G, Hurtado JC, et al., (2022) Diagnostic Performance of Six Rapid Antigen Tests for SARS-CoV-2. Microbiol Spectr 10:e0235121.

28. Flinck H, Kerimov D, Luukinen B, Seiskari T, Aittoniemi J, et al., (2022) Evaluation of the Roche-SD Biosensor rapid antigen test: Antigen is not reliable in detecting SARS-CoV-2 at the early stage of infection with respiratory symptoms. Diagn Microbiol Infect Dis 102:115628.

29. Shin H, Lee S, Widyasari K, Yi J, Bae E, et al., (2022) Performance evaluation of STANDARD Q COVID-19 Ag home test for the diagnosis of COVID-19 during early symptom onset. J Clin Lab Anal 36:e24410.

30. Wertenauer C, Brenner Michael G, Dressel A, Pfeifer C, Hauser U, et al., (2022) Diagnostic Performance of Rapid Antigen Testing for SARS-CoV-2: The COVid-19 AntiGen (COVAG) study. Front Med (Lausanne) 9:774550.

31. Control ECfDPa. Considerations for the use of saliva as sample material for COVID-19 testing. 3 May 2021.

32. Scohy A, Anantharajah A, Bodéus M, Kabamba-Mukadi B, Verroken A, et al., (2020) Low performance of rapid antigen detection test as frontline testing for COVID-19 diagnosis. J Clin Virol 129:104455.

33. Mak GC, Cheng PK, Lau SS, Wong KK, Lau CS, et al., (2020) Evaluation of rapid antigen test for detection of SARS-CoV-2 virus. J Clin Virol 129:104500.

34. Control ECfDPa. Options for the use of rapid antigen tests for COVID-19 in the EU/EEA and the UK. 19 November 2020.

35. Mercer TR, Salit M (2021) Testing at scale during the COVID-19 pandemic. Nat Rev Genet 22:415-426.