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Access to and utilisation of COVID-19 antigen rapid diagnostic tests (Ag-RDTs) among the general population in Phnom Penh: a cross-sectional study

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ABSTRACT

Objectives Globally, there is a lack of evidence regarding access to and utilisation of antigen rapid diagnostic tests (Ag-RDTs). This might hinder public health interventions to increase testing. We conducted a survey to understand access to and utilisation of COVID-19 Ag-RDT among residents in Phnom Penh, Cambodia.

Design This is a representative household survey using linear regression models with random effects to account for clustering and a logistic model with random effects to assess factors associated with Ag-RDT access.

Setting We conducted the study in 10 villages in Phnom Penh between August and mid-September 2022.

Participants We enrolled one member per household (n=280), aged between 18 and 65 years.

Outcome measures Both access and utilisation were defined at the individual level (self-reports). We defined access as having undergone COVID-19 rapid testing within 6 months and utilisation as having administered this test (to themselves or others) within 12 months, prior to the study interview.

Results In a clustering-adjusted linear model, access to Ag-RDTs among the general population from the 10 villages was 34% (n=95) and utilisation was 28% (n=77). Price and advice from the pharmacist were commonly reported to be the main selection criteria for Ag-RDTs, with 41% (n=111) and 62% (n=175), respectively. In the logistic model, those with higher educational attainment were more likely to have access to the Ag-RDT compared with those with lower education levels (adjusted OR4.42, 95% CI 1.82 to 10.74).

Conclusions Unfamiliarity with Ag-RDT tests and low education levels negatively affect access and utilisation of Ag-RDTs among the general population in Phnom Penh.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ With zero refusals and a very small number of replacement households, chances of selection bias due to differential participation by demographic factors are highly unlikely in this study.
⇒ Assessment of the main outcomes and other variables was based on self-reports, potentially leading to biased estimates.
⇒ The study results might have limited generalisability, particularly among individuals residing outside of Phnom Penh and due to changing public health responses to COVID-19 over the course of the pandemic.

INTRODUCTION

Since early 2020, when the first case of COVID-19 was reported in Cambodia,[1] various diagnostic technologies have played important roles in quickly identifying cases for timely public health measures. Since their formal introduction into the Cambodian market around July–August 2021, antigen rapid diagnostic tests (Ag-RDTs) quickly became essential point-of-care tests as screening tools in healthcare facilities and by the general public in the privacy of their homes.

Compared with PCR tests, which remain the gold standard for diagnosing clinical COVID-19 infection, Ag-RDTs are cheap, portable and easy to administer and have excellent accuracy for rapidly identifying both symptomatic individuals and asymptomatic individuals with high viral loads,[2 3] so that they may self-isolate, thereby interrupting chains of transmission. COVID-19 testing has been essential since the early stages of the pandemic, not only for diagnostic purposes but also for resuming many activities within countries and across borders (eg, international travel and economic activities). As the pandemic continued, the ability to develop and adapt responses increasingly depended on the availability of rapid testing and diagnostic strategies.[4 5] In Cambodia, PCR tests had been used for all inbound travellers since the start of the pandemic free of charge until July 2022, when the Ministry of Health (MoH) decided to exempt from quarantine for inbound unvaccinated or not fully vaccinated travellers, but they were required to

Figure 1 Geographic location of Phnom Penh.

take a rapid antigen COVID-19 test on arrival.[6] Several Ag-RDTs had been approved for use[7] and been made available widely on the market for purchase without prescription. They were mainly used for screening purposes, free of charge, at public hospitals, certain enterprises/institutions and at other public entry ports like airports, official events, etc. At private clinics or hospitals, a negative rapid test result was required before consultation or hospitalisation, and in general, testing was provided at a cost. The price of Ag-RDTs varied from around US$1–10 per test. Despite their importance in the efficient and early detection of COVID-19-infected individuals,[8] no study had been conducted at that time to understand the access to and utilisation of Ag-RDTs in Cambodia. Past studies conducted in the region focused more on PCR testing and associated factors.[9 10] We conducted our study in Cambodia's capital city, Phnom Penh (figure 1). It is home to more than 2 million people and, compared with other provinces, is where the largest proportion of the Cambodian population resides[11 12] (figure 1). Given the heightened risk of transmission in more densely populated settings,[11 13–15] we focused our investigation on Phnom Penh to help inform improving rapid test uptake and access rates among Phnom Penh residents, including timely diagnostic and linkage to treatment of certain subgroups who might be at higher risk of COVID-19-related morbidity and mortality, such as the elderly or people with important comorbidities. In this context, we conducted the present household-level study to determine the access to and utilisation of Ag-RDTs among the general population living in Phnom Penh in 2022.

METHODS

Study design and contexts

This is a representative household-level survey conducted among 280 household members residing in 10 villages in Phnom Penh from mid-August to September 2022. For context, Phnom Penh is administratively divided into districts, subdistricts and villages, which are the smallest geographic unit. There is, in general, no fixed number of households in a village; the village size could therefore vary greatly in terms of household numbers.

Study population

The participants aged between 18 and 65 years were recruited through a multistage sampling process. We included only adults up to 65 years based on the assumption that those above that age are highly unlikely to use the Ag-RDT (retirement age in Cambodia) but more likely to stay home during the time of the survey, which makes including them highly likely without the age restriction. In the first stage, the list of all villages in the Phnom Penh area and the corresponding number of families in each village were obtained from the latest Cambodian census (2019). We then selected 10 villages using probability-proportional-to-size (PPS) sampling out of the total 956 villages in Phnom Penh. With PPS, each village had an assigned number of households to be recruited determined by their actual size (see online supplemental table 1 for details). In the second stage, we obtained an up-to-date list of all households/families within each selected village. Using a random number table (integrated into the Open Data Kit or ODK-based application on the tablet used for data collection), the study team then randomly selected the required number of households from each of those villages. In the third and final stage, only one of the eligible household members was randomly selected to participate in the survey. The selection process here is similar to that of selecting households.

We defined access as having undergone Ag-RDT for COVID-19 within the past 6 months of the interview date and described where they had undergone the testing. Utilisation was defined as having administered the Ag-RDT either to oneself or to others within the past 12 months. This information collected was based on self-report.

The sample size was calculated based on the assumption that the Ag-RDT access in Cambodia was 30%, using the formula in which precision is used for sample size estimation: $n = Z^2_{1-\propto/2} P(1-P)/d^2$, where P is the estimated proportion and d is the targeted precision level (~6% in our study); the final sample size was then calculated by multiplying the sample size n with design effect (deff), estimated based on the formula $deff = 1 + \rho(m-1)$, where ρ is the intraclass correlation (ICC). The ICC value of 0.01 had been chosen based on previous household seroprevalence surveys conducted in Cambodia and other studies.[16 17] Participant inclusion criteria were being aged between 18 and 65 years, residing within the selected household for at least 3 months prior to the survey date and provided informed consent.

Data collection processes

Prior to survey administration, the data collectors underwent training on how to obtain verbal informed consent and how to use tablets to collect/record information from

study participants via computer-assisted personal interviewing (CAPI). All data collectors underwent training with human subjects certified trainers.

Information collected from each selected household member for the survey included demographic characteristics, access and utilisation of Ag-RDTs (via CAPI) using tablets. At each selected village, the study team went to each selected household with designated village volunteers to meet the household members. If the selected household member was not home at the time of the survey administration, the study team left the study information sheet with the other present household members, took the selected member's contact information and called them to explain the study and arranged for another meeting with them at a later date. Of note, none of the participants who had been called back for the survey refused to participate; therefore, no replacement had to be made. Households, where none of the members were present (approximately five houses), were systematically replaced (the data collectors were trained to replace these households with the nearest household located on the right side of the original selected household). The interview took place inside the interviewee's home, in general, although sometimes this also happened within the house vicinity where seating arrangement was more convenient for everyone.

Analysis

The study participants' de-identified data were stored on the University of Health Sciences's server, with access being restricted to only the designated study's data personnel and team.

Means and SD were calculated for continuous variables (normality checked) and proportions and percentages for categorical variables. We fitted a linear model in univariate analysis and reported on these proportions and percentages for each categorical variable, using a mixed-effects model to account for variability between clusters at the village level. Similarly, for the logistic mixed-effects model, we modelled Ag-RDT access as a function of demographic factors and reported crude and adjusted ORs from the mixed-effects model, accounting for clustering and potential confounding variables, which we selected based on prior knowledge and literature review.[18] All analyses were conducted using STATA V.17 (Copyright 1985–2021 StataCorp, Texas, USA).

Patient and public involvement

Household members, village authorities and volunteers had been involved in the data collection of the study. Preliminary results of the study were presented in Phnom Penh in November 2022, with village volunteers and chiefs, high-level representatives and guests from the MoH, students from the University of Health Sciences and relevant partner organisations and researchers in attendance.

RESULTS

Demographics

We approached 285 households and collected information from 280 household members residing in the 10 selected villages in the Phnom Penh area. There were five households with no occupants during the study visits, and we could not obtain any information about the household, so they were replaced. Overall, we found 34% (n=95) and 27% (n=77) of respondents reported having accessed and used Ag-RDT. We presented in table 1 the access and utilisation among the study participants by selected demographic characteristics. About 32% (n=89) of the study volunteers in our survey were men, and the mean age was 40 years (SD 13). About 37% (n=105) of our study volunteers had completed high school or higher educational degrees. Most of them worked in service and sales, 43% (n=121) and only about 8% (n=23) were unemployed or students.

Among the 89 male study participants, 40% (n=36) reported having recent access to Ag-RDT and among women (n=191), only 32% (n=59) of them reported having access to Ag-RDT. Similarly for utilisation, more men (34% or n=31) reported the utilisation of the Ag-RDT compared with women (25% or n=46). We also observed that the number of study participants in the oldest age group reported the lowest rates of both Ag-RDT access and utilisation (24% and 10%, respectively) compared with the younger age groups, where both access and utilisation rates ranged from 30% to 40%. Study participants who reported the highest access and utilisation rates were those who had completed high school or higher in terms of education (around 48%–49%), whereas those who had none to less than primary education reported the lowest rates of access and utilisation (21% and 5%, respectively).

Access to Ag-RDT

Although all of the study participants reported having heard of Ag-RDTs, only 34.5% (n=95) had access to these rapid tests (table 2).

The majority of study participants (64% or n=175) knew of Ag-RDT from social network platforms, such as Facebook, followed by families and friends, with 54% (n=149) and 41% (n=116), respectively. A substantial number of our interviewees also knew Ag-RDT from watching television (39% or n=108).

About 25% (n=70) of the study participants reported that they had obtained some Ag-RDT free of charge within the past 12 months, and almost everyone who had done so (n=63) agreed that it was quite easy to obtain them without payment. Additionally, we observed that most of them obtained the Ag-RDT for free from their workplace (n=29) and from local authorities (n=21). Besides obtaining these rapid tests for free, some also bought these tests for use (n=101), and among them, 88% (n=88) agreed that buying these Ag-RDTs was, in fact, easy. We also found that the majority of our study participants who actually obtained the Ag-RDT for free (n=29) actually used these tests before entering events

Table 1 Access and utilisation by selected demographics among study participants (n=280), Foundation for Innovative New Diagnostics Accelerator Project, 2022, Cambodia

	Study participants (n=280)	Access to Ag-RDT (n=95)		Utilisation of Ag-RDT (n=77)	
Characteristics	N (%)	N (%*)	%† (95% CI)	N (%*)	%† (95% CI)
Gender					
Male	89 (31.8)	36 (40.4)	40.4 (30.2 to 50.6)	31 (34.8)	34.4 (21.6 to 47.2)
Female	191 (68.2)	59 (30.9)	31.7 (23 to 40.3)	46 (24.1)	24.7 (16.6 to 32.7)
Age (mean, SD)	(40.2 to 13.0)	(37.7 to 11.7)		(35.2 to 9.6)	
18–27 years	49 (17.5)	19 (38.8)	38.8 (25.1 to 52.4)	17 (34.7)	34.7 (21.4 to 48)
28–37 years	76 (27.1)	28 (36.8)	36.9 (25.4 to 48.4)	29 (38.2)	40 (26.7 to 53.3)
38–47 years	66 (23.6)	27 (40.9)	40.3 (24.6 to 56)	22 (33.3)	33.3 (21.9 to 44.7)
48 years and above	89 (31.8)	21 (23.6)	23.6 (14.8 to 32.4)	9 (10.1)	10.1 (3.8 to 16.4)
Education					
None to less than primary	62 (22.1)	13 (21.0)	21 (10.8 to 31.1)	3 (4.8)	4.7 (0 to 10.4)
Secondary or less	113 (40.4)	32 (28.3)	29.7 (17.8 to 41.7)	22 (19.5)	19.9 (12 to 27.8)
Completed high school or higher	105 (37.5)	50 (47.6)	47.6 (38.1 to 57.2)	52 (49.5)	49.5 (39.9 to 59.1)
Occupation					
Government/law enforcements	24 (8.6)	16 (66.7)	66.7 (47.8 to 85.5)	8 (33.3)	27.2 (3 to 51.5)
Private company/NGO	33 (11.8)	21 (63.6)	62.9 (45.4 to 80.3)	20 (60.6)	60.6 (43.9 to 77.3)
Housewife	73 (26.1)	15 (20.5)	20.5 (11.3 to 29.8)	16 (21.9)	21.9 (12.4 to 31.4)
Unemployed/student	23 (8.2)	10 (43.5)	43.5 (23.2 to 63.7)	9 (39.1)	39.1 (19.2 to 59.1)
Service/sale	121 (43.2)	31 (25.6)	27.7 (15.1 to 40.3)	23 (19.0)	19 (12 to 25.9)
Others	6 (2.1)	2 (33.3)	33.3 (0 to 71)	1 (16.7)	16.7 (0 to 46.5)

Note: Some categories might not add up to 100% due to rounding from mixed model.
*Row percentages reported here are raw percentages (not accounting for clustering effect of villages).
†Percentages reported here are linear model estimates (accounting for clustering effect of villages).
Ag-RDT, antigen rapid diagnostic test.

and places and not for symptom-based testing. Also, it is important to note that about 90% of study participants agreed that obtaining Ag-RDTs for free was, in fact, easy, which implies that the cost of rapid tests might not play an important role, as they could easily get these tests free of charge.

Utilisation of Ag-RDT

About 28% (n=77) had administered the Ag-RDT to themselves or others within the past 12 months. Among these, 12% (n=32) reported being familiar with administering these rapid tests to themselves as well as to others. The majority of participants reported that they would use rapid tests if they or their families had suspected symptoms or had been exposed (97% or n=273). When asked to describe the next steps if their rapid test result was to return positive, a large proportion of our study participants reported that they would seek advice from public healthcare providers (46% or n=134). Finally, the study participants were also asked to define their selection criteria for the COVID-19 rapid tests, and the majority of them reported that price (41% or n=111) and recommendation from a pharmacist (62% or n=175) were their main criteria for selecting an RDT. More details on access and utilisation can be found in table 2.

Factors associated with Ag-RDT access

In both crude and adjusted mixed-effect logistic models, only education and occupation appeared to be associated with Ag-RDT access (table 3).

Those who received higher education (completed high school degrees or higher) were more likely to have access to the Ag-RDT compared with those who had none or less than primary education (OR 7.44, 95% CI 3.73 to 14.8 and aOR 4.42, 95% CI 1.82 to 10.74), in the crude and adjusted logistic mixed models, respectively. Furthermore, compared with those who worked in the government and military, other occupations, such as those who work in sales/services or housewives, appeared to be likely to have access to Ag-RDT testing within the past 6 months (aOR 0.14, 95% CI 0.04 to 0.45 and aOR 0.17, 95% CI 0.06, to 0.50), in the case of sale/service work and housewives, respectively. Those in the oldest age group (48 years and above) appeared to be less likely to have had access to Ag-RDT compared with those in the youngest age group (18–27 years) (OR 0.48, 95% CI 0.22 to 1.05). However, in the adjusted mixed-effects model,

Table 2 Access to and utilisation of COVID-19 Ag-RDT among study participants (n=280), Foundation for Innovative New Diagnostics Accelerator Project, 2022, Cambodia

Characteristics	N/N	%*	%†	95% CI
Access to COVID-19 Ag-RDT				
Ever heard of Ag-RDT				
Yes	280/280	100	100	–
No	0/280	–	–	–
Ever underwent Ag-RDT				
Yes	183/280	65.4	65.3	59.7 to 70.9
No	97/280	34.6	34.7	29.1 to 40.2
Had Ag-RDT within the past 6 months				
Yes	95/280	33.9	34.5	26.1 to 42.8
Longer than 6 months ago and never	185/280	66.1	65.5	57.1 to 73.9
Obtained Ag-RDT for free within the past 12 months				
Yes	70/280	25.0	24.7	18.9 to 30.5
No and never at all	210/280	75.0	75.3	69.5 to 81.1
Last Ag-RDT obtained for free from‡				
Public health facility	11/70	15.7	16.7	4.1 to 29.2
Workplace	29/70	41.4	41.4	28.3 to 54.6
Friends and families	9/70	12.9	12.8	5 to 20.7
Authorities/Phum/Sangkat	21/70	30.0	28.8	13.5 to 44.2
Heard (knew) of Ag-RDT from				
Workplace	60/280	21.4	20.6	13.8 to 27.4
Friends	116/280	41.4	41.4	35.6 to 47.2
Family members	149/280	53.2	54.5	45.9 to 62.9
Social network	175/280	62.5	63.7	56.1 to 71.2
Television	108/280	38.6	39.5	32.7 to 46.3
Healthcare workers	14/280	5.0	5.0	2.4 to 7.5
Authorities/Phum/Sangkat	32/280	11.4	10.5	4.9 to 16.1
Obtaining last Ag-RDT for free was‡				
Easy	63/70	90.0	90.0	82.9 to 97
Hard	4/70	5.7	5.7	0.3 to 11.1
Neither hard or easy	3/70	4.3	4.3	0 to 9
Buying last RDT was§				
Easy	88/101	87.1	87.7	78.8 to 96.6
Hard	9/101	8.9	8.9	3.3 to 14.5
Neither hard or easy	4/101	4.0	3.9	0.1 to 7.8
The cost of last Ag-RDT bought was				
Cheap	25/101	24.8	23.7	11.7 to 35.7
Expensive	36/101	35.6	35.6	26.3 to 44.9
Neither expensive or cheap	40/101	39.6	40.9	29.9 to 51.9
Reasons for getting last (free) Ag-RDT¶				
Respiratory symptoms	11/70	15.7	15.9	6.4 to 25.4
Fever	4/70	5.7	5.7	0.3 to 11.1
Exposure to known positive case	7/70	10.0	10.0	2.9 to 17
Exposure to suspected positive case	11/70	15.7	16.8	4.1 to 29.6
Reserve for later use	12/70	17.1	17.1	8.3 to 25.9
Required for entering events/places	29/70	41.4	41.4	29.2 to 53.5

Continued

Table 2 Continued

Characteristics	N/N	%*	%†	95% CI
Utilisation of COVID-19 Ag-RDT				
Administered Ag-RDT to oneself/others within the past 12 months				
Yes	77/280	27.5	28.0	20.4 to 35.7
Self-administered Ag-RDT only	34/280	12.1	12.1	8.2 to 16.1
Administered Ag-RDT to others only	11/280	3.9	3.9	1.6 to 6.2
Self-administered Ag-RDT and administered it to others	32/280	11.4	11.7	6.7 to 16.7
Never either way	203/280	72.5	72.0	64.3 to 79.6
If RDT (+), the immediate next step should be**				
Seek advice from public providers	134/280	47.9	46.3	38.1 to 54.5
Seek advice from private providers	25/280	8.9	9.0	5.5 to 12.5
Seek confirmatory PCR	12/280	4.3	4.3	1.9 to 6.6
Retest with another Ag-RDT	2/280	0.7	1.0	0 to 2
Self-isolate at home	73/280	26.0	26.1	20.5 to 31.6
Seek medications from pharmacy	28/280	10.0	10.0	6.5 to 13.5
Selection of RDT depends on				
Price (cheaper, better)	126/280	45.0	45.0	39.2 to 50.8
Country of manufacturing	58/280	20.7	21.2	15.2 to 27.2
Recommendation from pharmacist	193/280	68.9	69.4	62.9 to 75.9
Test packaging	44/280	17.1	11.0	10.3 to 23.9
Nature of specimen required	16/280	5.7	6.3	2.3 to 10.3
Quality	30/280	10.7	11.0	6.6 to 15.4
RDT should be used when one has				
Respiratory symptoms and/or fever	273/280	97.5	97.5	96.7 to 99.3
Been exposed to positive COVDI-19 case	3/280	1.1	1.0	0 to 2.3
Not sure	4/280	1.4	1.4	0 to 2.8

Note: Some categories might not add up to 100% due to rounding from mixed model.
*Row percentages reported here are raw percentages (not accounting for clustering effect of villages).
†Percentages reported here are linear model estimates (accounting for clustering effect of villages).
‡Subset to those who had obtained RDT for free within the past 12 months, single answer only.
§Subset to those who had bought Ag-RDT within the past 12 months, single answer only.
¶Subset to those who had obtained Ag-RDT for free within the past 12 months, multiple answers allowed.
**Single answer only.
Ag-RDT, antigen rapid diagnostic test.

the association disappeared (aOR 0.69, 95% CI 0.27 to 1.78). Similarly, the access to Ag-RDT did not appear to differ by sex, both in the crude and adjusted models (OR 0.66, 95% CI 0.39 to 1.13 and aOR 1.19, 95% CI 0.62 to 2.29). Upon observing a suboptimal rate of access (34%), we did not extend the same analysis for utilisation; we reasoned that low utilisation was most likely due to low access. It should be noted that because the cost of Ag-RDTs was not associated with access or education (results not shown) and obtaining free rapid tests was easy for the majority of participants, the variable on test cost was not entered into the model.

DISCUSSION

This was the first study to examine access to and utilisation of Ag-RDTs for COVID-19 among the general population in Cambodia, and quite possibly in Southeast Asia, since most studies focused on PCR testing. We found rates of access and utilisation among the study at 34.5% and 28%, respectively, and they seemed to differ by occupation and educational levels. For context, new cases of COVID-19 in Cambodia started decreasing in the 6–8 months prior to our study—from about 400 new cases reported in early 2022 (8 months prior to the survey) to around 100 in early July 2022 (1 month prior to the survey),[6 19] after which date the MoH and Inter-Ministerial Committee to Combat COVID-19 in Cambodia started implementing the Operational Guidelines for Use of COVID-19 Ag-RDTs for Private Health Providers, Non-health Government Institution-Entities, Points of Entry, Private Companies, Factories-Enterprises and other Business Locations and individuals.[20] Since issuing these guidelines, most public

Table 3 Factors associated with Ag-RDT access among study participants (n=280), Foundation for Innovative New Diagnostics Accelerator Project, 2022, Cambodia

Characteristics	Had access to Ag-RDT* (n=95)					
	OR	95% CI	P value	aOR†	95% CI	P value
Sex						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.66	0.39 to 1.13	0.13	1.19	0.62 to 2.29	0.60
Age						
18–27 years	Ref	Ref	Ref	Ref	Ref	Ref
28–37 years	0.94	0.44 to 1.99	0.87	1.04	0.43 to 2.55	0.92
38–47 years	1.03	0.47 to 2.23	0.94	1.4	0.56 to 3.50	0.47
48 years and above	0.48	0.22 to 1.05	0.06	0.69	0.27 to 1.78	0.45
Education						
None to less than primary	Ref	Ref	Ref	Ref	Ref	Ref
Secondary or less	1.90	1.00 to 3.60	0.05	1.74	0.87 to 3.50	0.12
Completed high school or higher	7.44	3.73 to 14.8	<0.001	4.42	1.82 to 10.74	0.001
Occupation						
Government/forces	Ref	Ref	Ref	Ref	Ref	Ref
Private company/NGO	0.89	0.29 to 2.73	0.84	0.75	0.24 to 2.41	0.63
Housewife	0.13	0.04 to 0.36	<0.001	0.14	0.04 to 0.45	0.001
Unemployed/student	0.37	0.11 to 1.24	0.11	0.38	0.10 to 1.49	0.17
Service/sale	0.18	0.07, to 0.46	<0.001	0.17	0.06 to 0.50	0.001
Others	0.27	0.04 to 1.91	0.19	0.33	0.04 to 2.51	0.28

*Underwent COVID-19 RDT within the past 6 months.
†Adjusted for gender, age, education and occupation.
Ag-RDT, antigen rapid diagnostic tests.

institutions (ministries, hospitals, etc) provided free testing or test kits to their employees, which could explain the relatively high testing rates among government staffs in our results. Others set up their own rules for testing their employees/clients using the operational guidelines as guidance to ensure the safety of the working environment, such as testing before entering public gatherings or events or testing every other day for those working in delivery service. At the time of the study's conduct, medical prescription was not required for COVID-19 testing (PCR or Ag-RDT), and most hospitals and testing centres offered them at no charge. However, in most private settings, the PCR tests for COVID-19 might cost about 6–10 times higher than the Ag-RDT, depending on the provider.

Access to Ag-RDTs

There had been several publications from the UK looking at COVID-19 testing access prior to our study. A research article published in 2022 examining motivations of individuals seeking COVID-19 rapid tests at community testing centres in two areas in England reported that about 35% of their study population had heard of rapid testing centres from their work, 8% from local authorities, 11% from Facebook and television.[2] These findings were similar to ours in that about 10% of our study participants heard of Ag-RDT from local authorities. However, we found much lower proportions of people who reported having heard of rapid tests from their workplace but higher proportions of those who reported having heard of rapid tests from social networks and television, at 64% and 39%, respectively. It is noteworthy that the study populations in both studies were very different. While the study population in the UK comprised employees in education, essential work and health,[2] the majority of household members in our study were in sales/services as an occupation. Therefore, in the UK study, many might know about rapid testing from their workplace. Moreover, in Cambodia, social network platforms, such as Facebook, and the internet are highly popular[21 22]; therefore, many more respondents were likely to hear of rapid tests from the internet and social pages in Cambodia. Access to Ag-RDT was higher among men in our study, but the opposite had been reported in two other studies.[23 24] Regardless, in our adjusted regression model, sex is not significantly associated with access to Ag-RDT; potentially this was due to our much smaller sample size compared with the two studies.

Utilisation of Ag-RDTs

According to the Morbidity and Mortality Weekly Report (MMWR) issued in March last year, about 11%

of their online survey respondents reported at-home rapid antigen COVID-19 test utilisation over the past 30 days.[25] We reported a 12% utilisation rate over the past 12 months. Although we did not show it, the numbers reported for the past month were also roughly the same in our study, as Cambodia started to see a significant decrease in COVID-19 cases from June to July 2022 (1–2 months prior to the survey). In their report, among those who did the rapid tests at home, 29% reported that they did the test because they had COVID-19 symptoms,[25] which is much higher than what was reported in our study (only about 16% of our study participants reported using their last free rapid test for symptom-based testing). Similarly, a French study also reported the majority of their study participants underwent self-testing due to the apparition of COVID-19 symptoms.[26] This difference is more likely due to the fact that the majority of our study participants actually underwent the last rapid test at the point of entry (a common requirement before either entering an event or a place in Cambodia during the time of the study) and not necessarily because they had COVID-19-related symptoms. In addition, both the American (MMWR) and French studies focused more on self-testing utilisation while ours also covered the use of Ag-RDTs on and by others. Another factor affecting the use of Ag-RDT is the test kit cost, which had been identified in a qualitative study conducted in the US as well as in a Chinese survey in 2022[27 28] as one of the main concerns of respondents. This is also in line with our findings, where about 36% of participants reported that the price of the Ag-RDT was expensive for them. The 2022 Chinese study[27] also reported that education level was positively associated with higher utilisation (or intent to utilisation), which is also consistent with our study results. This might be due to the working status of those with high education, which requires them to travel and join events more often than those with lower educational backgrounds. Also worth highlighting was the high proportion of respondents who reported that their choice of the Ag-RDT depended on the recommendation from the pharmacists. In Cambodia, according to past studies, the majority of Cambodians seek care from the private sector (including private hospitals, clinics, pharmacies, etc),[29 30] and because prescriptions are not generally required for getting medication at pharmacies,[31] the pharmacists are usually where people go first for their minor health problems or questions, although the roles of pharmacists in the Cambodian health system have yet to be studied in detail.

It is important to note that study sites were very diverse in terms of their population composition and socioeconomic status and included sites in central Phnom Penh and in the suburban parts of the capital city (figure 2). While our study population was broadly representative of the wider Phnom Penh area as a whole, caution should be taken when attempting to generalise our findings to populations residing outside of Phnom Penh. It is also important to note that the testing uptake, access and utilisation might have changed substantially after the study had been conducted, as the pandemic and subsequently, the response evolved. Second, our study had a low proportion of male participants compared with females (one-third), which might also limit the study's generalisability. Regardless, this is a common finding for household surveys in Cambodia; the latest Cambodia Demographic and Health Survey also had a similar proportion of male respondents.[32] In addition, we already observed that the testing access was not different among men and women in our study. Third, we were not able to conduct a comprehensive assessment of the socioeconomic status of the selected households, as asking people about their income is usually considered impolite in Cambodia. However, we did include complementary questions on the education and occupations of each selected member, which are also useful proxy indicators for a person's economic status. Although this is not a reflection of the household status as a whole, it reflects the individual's ability to afford the test in general, which was the main research question. Finally, we asked our study participants to recall over a period of 12 months their practices regarding rapid testing for COVID-19, which is a considerable amount of time for recall. However, administering rapid tests during the pandemic is rather memorable as an event, and Cambodia had only started to really feel the effect of the COVID-19 pandemic starting in 2021, when mass testing and other public health measures, including travel bans and physical and social measures, were beginning to really take off. There were also several major pandemic-related events as reference points of timeframe to help the study participants better recall their testing practices. Additionally, there were many pictures for memory aid that had been integrated into the e-questionnaires, helping participants with their recall. Despite these limitations, our study also presented several strengths. Our work is the first one to

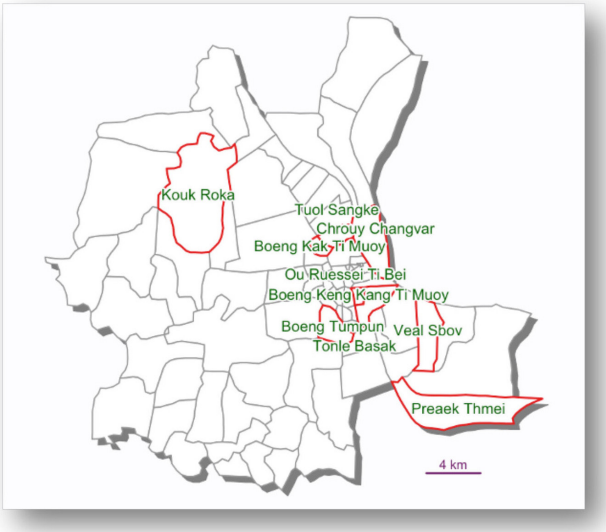

Figure 2 Geographic distribution of the 10 selected subdistricts (Sangkat) in Phnom Penh.

examine testing access and utilisation among the general population in the country. In addition, our study had zero refusals, zero household members who needed to be replaced (due to their absence at the time of data collection) and very limited numbers of households (around five households) that actually had to be (systematically) replaced. This suggests that a selection bias due to differential participation rates across various demographic profiles and geography is highly unlikely in our survey.

The Ag-RDTs is one of the important public health tools for fighting the COVID-19 pandemic, as it is simple to use, can provide rapid results and has been proven to detect almost all of the persons with high viral loads, who are at the greatest risk of transmitting the virus.[33]

Implications for policy and practices

Although access to and utilisation of COVID-19 Ag-RDTs have been studied elsewhere, there are country-specific contexts that are helpful to understand when developing strategies for improving testing uptake and utilisation; for example, the public trust in the pharmacists when choosing the rapid tests that were reported in our study or the fact that many people used the tests but only because they were required for entry (at an event or place). The effective intervention needs to take into account these contextual factors that vary from one country to another and from one population to another to ensure the successful delivery of the intervention. Several factors could affect the utilisation of Ag-RDTs, and one important factor is the low access to these rapid tests, which could be due to the costs of these tests and how easy (or difficult) it is to administer the test. In Cambodia, pharmacists are, in general, the first people from whom advice is sought over minor health-related issues, and this fact remained true in the pandemic context, as demonstrated in our study findings. This highlights the important role that health professionals in the private health sector, such as pharmacies and clinics, could play in getting correct information directly to the general public and where applying self-administered public health measures is feasible, especially during a public health crisis. In addition, we also saw how village authorities and volunteers worked to support the health sector to curb the spread of COVID-19 through sharing information on testing points with individuals in the communities as well as helping them get access to these rapid tests when they are needed. This is, of course, of particular importance in the event of lockdown measures, where entries to and exits from affected communities are restricted. Other than these, friends, neighbours and workplace could potentially be additional and crucial sources of information, support and distribution points of public health interventions, which include (but are not limited to) rapid screening tests.

CONCLUSIONS

Lack of access to and utilisation of simple screening tools such as Ag-RDTs could certainly hinder the control of the disease transmission and subsequently the pandemic. Although there are reported limitations to the COVID-19 Ag-RDTs regarding their accuracy (compared with the molecular testing methods), their ability to screen infected individuals with high viraemia and provide rapid results remains undoubtedly one of the most important public health tools in the pandemic response. Ensuring equity in access and uptake of rapid diagnostic tools in the general population is crucial for everyone so that they can protect themselves as well as seek appropriate treatment and support in a timely manner. Multiple factors could affect rapid test access and utilisation among individuals, including, among others, education and suggestions from pharmacists.

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Contributors KS conducted literature search, designed the study, collected and analysed the data, interpreted results, wrote the manuscript and created figures. FV conducted literature search, designed the study and guided data analysis and interpretation. SK and VO conducted literature search and collected the data. JK, AJV and VS conceptualised the study idea, conducted literature search and guided data collection, analysis and result interpretation. All authors provided critical feedback and shaped the final manuscript. All authors have read and agreed to the published version of the manuscript. KS is responsible for the overall content as guarantor.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

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