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COVID-19 Antibody in Thai Community Hospitals

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ABSTRACT

Objectives: We aimed to explore the seroprevalence of hospital staffs comparing to preprocedural patients in Thai community hospitals to shed light on the situation of COVID-19 infection of frontline healthcare workers in low infection rate countries where mass screening was not readily available.

Design: Cross-sectional study.

Setting: 52 community hospitals in 35 provinces covered all region of Thailand

Participants: 857 participants consisted of 675 hospital staff and 182 pre-procedural patients

Outcome measure: COVID-19 seroprevalence using a locally developed rapid IgM/IgG test kit

Results: Overall, 5.5% of the participants (47 of 857) had positive immunoglobulin M (IgM), 0.2% (2 of 857) had positive immunoglobulin G (IgG) which both of them also had positive IgM. Hospitals located in the central part of Thailand had the highest IgM seroprevalence (11.9%). Preprocedural patients had a higher rate of positive IgM than the hospital staff (12.1% vs. 3.7%). Participants with present upper respiratory tract symptoms had a higher rate of positive IgM than those without (9.6% vs. 4.5%). Three quarters (80.5%, 690 of 857) of the participants were asymptomatic, of which, 31 had positive IgM (4.5%) which consisted of 20 of 566 healthcare workers (3.5%) and 11 of 124 preprocedural patients (8.9%).

Conclusions: COVID-19 antibody test could detect a substantial number of potential silent spreaders in Thai community hospitals. Antibody testing should be encouraged for mass screening, especially in asymptomatic individuals.

Trial registration: Thai Clinical Trials Registry: TCTR20200426002

MeSH Keywords: COVID-19, severe acute respiratory syndrome coronavirus 2, Seroepidemiologic Studies, Hospitals, Thailand

Strengths and limitations of this study

► This study covered all regions in Thailand and consisted of community hospitals from 35 out of 77 provinces.

► We used a locally developed IgM/IgG test kit with high internal validation to shed light on the actual COVID-19 situation in an area in which PCR testing was not readily available.

► This study provided a real-life experience to gather crucial information despite limited and restricted resources.

► We did not have a chance to perform the serological test among the COVID-19 confirmed cases as the mild case had to get quarantined and the moderate and severe ones were referred to a higher level of care, which could affect the seroprevalence.

► We could not perform multiple serological tests at different time points as doing so was not approved by the ethics committee.

INTRODUCTION

Polymerase chain reaction (PCR) was introduced as a diagnostic test of choice for coronavirus disease 2019 (COVID-19) infection. However, it might not be readily available or affordable in many facilities and could pose an unnecessary risk to the healthcare providers during the specimen collection. Besides, a recent study raised a concern of false-negative results from the PCR test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in patients with high pretest probability and encouraged the development of a highly sensitive test.[1] In Thailand, the PCR test was offered in suspected individuals with strict criteria during the initial phase of the COVID-19 pandemic. As a more feasible, cheaper, and safer alternative to the PCR, the antibody test is not only useful for an epidemiological investigation but could also be used for mass screening of potential silent spreaders—asymptomatic COVID-19 individuals.[2]

Hospital is one of the best venues for getting and spreading pathogens. There are two types of people in the hospital who potentially are silent spreaders and need antibody testing: (1) healthcare workers who have a relatively higher risk of infection than laypersons, and (2) asymptomatic patients who need procedural treatment or operation but do not meet the criteria for PCR testing.

METHODS

Study Population

From 8th April to 26th June 2020, hospital staff and patients who needed procedural treatment or operation visiting the hospital during the recruiting period and did not meet the national PCR testing criteria in 244 hospitals (215 community hospitals and 29 general hospitals) from all regions of Thailand were recruited for antibody testing in their community hospital. Hospitals included in the study came from a national survey about willingness to use antibody testing for COVID-19 screening. Of 215 community hospitals, data from 52 hospitals (24.2%) in 35 provinces from all regions which could be considered representative of community hospitals across Thailand were readily available for the analysis performed on June 29, 2020. Participants with active symptoms meeting national criteria for PCR testing were quarantined and excluded. Participants were asked to answer a questionnaire about risk history for COVID-19, recent symptoms within the past two weeks, and previous PCR test results if available.

National criteria for PCR testing for COVID-19

National criteria for PCR testing for COVID-19 for symptomatic layperson during the study period included fever with one of the upper respiratory infection symptoms (cough, rhinitis, sore throat, anosmia, tachypnea, or dyspnea) and one of risk history (history of travel to a high-risk area, an occupation involving tourists, crowded place, or contact with many people, history of going to crowded place in the community, or history of close contact confirmed COVID-19 case) within 14 days before the onset of symptoms. For symptomatic healthcare workers, the criteria were less strict. Either fever or one of the upper respiratory infection symptoms was sufficient for PCR testing. During the recruiting period, there was almost impossible for an asymptomatic person to get PCR tested.

Antibody testing

Baiya Rapid COVID-19 IgG/IgM test kit (Baiya Phytopharm, Thailand) which reports the presence of immunoglobulin M (IgM) and immunoglobulin G (IgG) qualitatively using lateral flow immunoassay technique and receptor-binding protein of spike protein of SARS-CoV-2for antigen, was used in this study free of charge. The internal validation of the test kit using the serum of 51 PCR confirmed COVID-19 cases and 150 controls showed sensitivity 94.1% (48 of 51) and specificity 98.0% (147 of 150) for IgM or IgG antibody. Of 51 PCR confirmed COVID-19 cases, 56.9% (29 of 51) were IgM+ IgG-, 37.3% (19 of 51) were IgM+ IgG+, 5.9% (3 of 51) were IgM- IgG-. No IgM- IgG+ was detected in 51 PCR confirmed COVID-19 cases from interval validation. Participants with positive IgM were encouraged to have a PCR test if available. There was no hospital or center readily available for neutralizing antibody testing during the study period.

Age-adjusted seroprevalence

PCR confirmed COVID-19 cases were obtained from the Thailand government report on June 30, 2020. Seroprevalence data were presented as unadjusted seroprevalence and compared with direct age-adjusted seroprevalence using combined participating population, Thailand population, and world population provided by world health organization (WHO) for 2000-2025 population.

Statistical analysis

Categorical data were presented with counts and percentages while continuous data were provided with median and interquartile range. The 95% confidence interval (CI) of the seroprevalence was calculated by Wilson's method using binomial probabilities. Correlation between seroprevalence and PCR confirmed COVID-19 prevalence was tested using Spearman's correlation. Missing data were excluded. A two-tailed $p < 0.05$ was considered statistically

significant. All data were analyzed using Stata 16.1 (College Station, TX).

Patient and public involvement statement

The research question and outcome measure were developed from both patient and public involvement. For patient involvement, visiting a hospital must not harm patients; however, the unknown status of COVID-19 infection in the pandemic period led to a doubtable situation of no harm. For public involvement, the national policy about the COVID-19 test at the study period made unstable situation among the public, a national survey was conducted to identify a situation in the community and general hospitals to find places that should be the priority for this study to provide more confidence situation for hospital visiting and working. Patients and hospital staff who participated in this study had a report for their serology status, and the results of this study would be disseminated not only to participants but also to the public via an online channel to provide evidence of the actual situation.

RESULTS

Community hospital demographic

Overall, 52 community hospitals from 46.1% of provinces in Thailand (35 of 76) which consisted of 58.2% of national population (35,416,545 of 60,892,671) participated in this study. Participation rates varied across regions—Northeastern (55%), Central (50.0%), Southern (42.9%), Northern (33.3%), and Eastern (28.6%) (supplementary table E1).

Participant demographic

From 52 community hospitals, 857 participants which consisted of 675 hospital staff and 182 pre-procedural patients were included in the study. Their median age was 37 years (interquartile range 27–45), 74.7% were female, 98.8% were Thai, and 80.5% were asymptomatic. The most common symptoms were cough (9.7%), rhinitis (7.5%), sore throat (6.4%), fever (5.7%), and dyspnea (3.5%). History of travel to the high-risk area was 6.0%, history of close contact to the confirmed COVID-19 case was 15.4%, and 14.5% had PCR negative (table 1). Forty-seven participants (5.5%, 95% CI 4.1 to 7.2) had IgM antibody against SARS-CoV-2 whereas the IgG antibody was found in two participants (0.2%, 95% CI 0.1 to 0.8). Participants from the Central region of Thailand had the highest IgM seroprevalence (11.9%, 95% CI 8.4 to 16.5), while the Northern region had the lowest seroprevalence (1.6%, 95% CI 0.3 to 8.7) (figure 1).

Table 1 Demographic details of participants

	All Participants N (%)	Hospital Staff n (%)	Pre-procedural Patients n (%)
Total	857	675	182
Median age, years (25th–75th percentile)	37 (27–45)	36.5 (28–45)	37 (25–53)
Male	207 (24.1%)	145(21.5%)	62 (34.1%)
Female	640 (74.7%)	521 (77.2%)	119 (65.4%)
Unspecified	10 (1.2%)	9 (1.3%)	1 (0.5%)
Thai	847 (98.8%)	671 (99.4%)	176 (96.7%)
Non-Thai	10 (1.2%)	4 (0.6%)	6 (3.3%)
Region			
North	61 (7.1%)	59 (8.8%)	2(1.1%)
Northeast	269 (31.4%)	220 (32.6%)	49 (26.9%)
Central	244 (28.5%)	183 (27.1%)	61 (33.5%)
South	109 (12.7%)	88 (13.0%)	21 (11.6%)
East	174 (20.3%)	125 (18.5%)	49 (26.9%)
History of travel to high-risk area			
Yes	51 (6.0%)	20 (3.0%)	31 (17.0%)
No	806 (94.0%)	655 (97.0%)	151 (83.0%)
History of close contact confirmed case			
Yes	132 (15.4%)	121 (17.9%)	11 (6.0%)
No	725 (84.6%)	554 (82.1%)	171 (94.0%)
Asymptomatic	690 (80.5%)	566 (83.9%)	124 (68.1%)
Symptomatic	167 (19.5%)	109 (16.1%)	58 (31.9%)
Fever	49 (5.7%)	17 (2.5%)	32 (17.6%)
Cough	83 (9.7%)	52 (7.7%)	31 (17.0%)
Rhinitis	64 (7.5%)	47 (7.0%)	17 (9.3%)
Sore throat	55 (6.4%)	37 (5.5%)	18 (9.9%)
Dyspnea	30 (3.5%)	3 (0.4%)	27 (14.8%)
Previous PCR status			
Negative	124 (14.5%)	77 (11.4%)	47 (25.8%)
Never tested	733 (85.5%)	598 (88.6%)	135 (74.2%)

Data were presented in counts and percentages unless otherwise specified.
PCR, polymerase chain reaction.

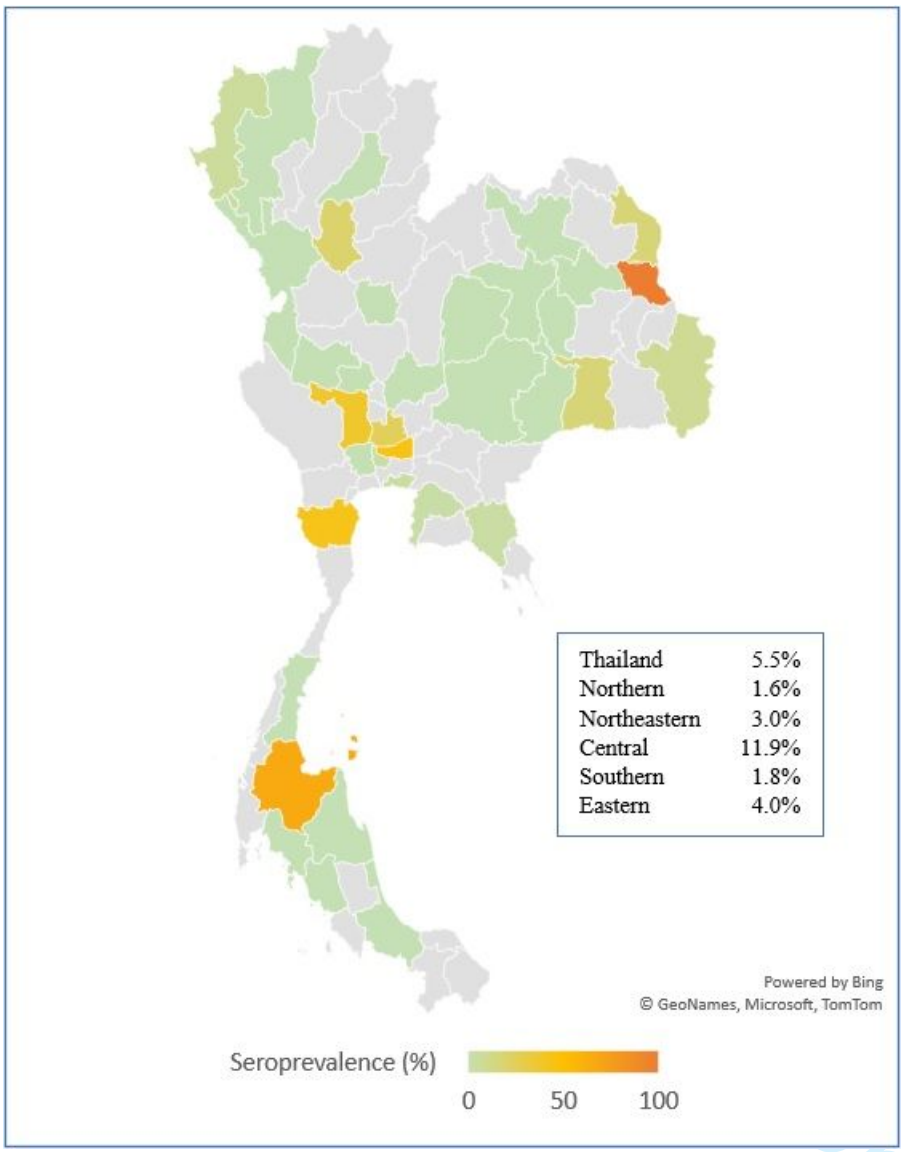

Figure 1 Unadjusted IgM Seroprevalence in Community Hospitals across Geographical Regions of Thailand

Age-adjusted immunoglobulin M (IgM) seroprevalence

Age-adjusted IgM seroprevalence with combined participating population showed almost similar results with unadjusted IgM seroprevalence. However, age-adjusted seroprevalence using Thailand population showed increasing seropositive rate in Thailand from 5.5% to 6.3%, Central region from 11.9% to 15.3%, and Northern region from 1.6% to 1.8%, while decreasing seroprevalence in Northeastern region from 3.0% to 1.6%, Eastern region from 4.0% to 2.8%, and Southern region from 1.8% to 1.5%. Adjusted with the world standard population

from the World Health Organization (WHO 2000-2025) showed decreasing trends of seroprevalence both overall and in most regions (table 2).

Table 2 Unadjusted and age-adjusted immunoglobulin M seroprevalence in community hospitals across geographical regions of Thailand

Regions	Unadjusted IgM Seroprevalence	Age-adjusted IgM Seroprevalence with Combined Participating Population	Age-adjusted IgM Seroprevalence with Thailand Population	Age-adjusted IgM Seroprevalence with World Standard Population
Thailand*	5.5%	NA	6.3%	5.1%
Northern	1.6%	2.2%	1.8%	2.1%
Northeastern	3.0%	3.0%	1.6%	1.5%
Central*	11.9%	11.9%	15.3%	12.2%
Southern	1.8%	2.4%	1.5%	1.2%
Eastern	4.0%	3.9%	2.8%	2.6%

* Not include Bangkok which has no community hospital.
IgM, immunoglobulin M; NA, not available; WHO, World Health Organization.

Participant characteristics and seroprevalence

Pre-procedural patients had an unexpectedly higher proportion of positive IgM than the hospital staff (12.1% vs. 3.7%), especially patients in the Central region of Thailand (27.9%, 95% CI 18.2 to 40.2) while patients in the Northern and Southern regions showed zero seroprevalences. Also, hospital staff in the Central region had the highest seroprevalence (6.6%, 95% CI 3.8 to 11.1) while those in the Northern region had the lowest (1.7%, 95% CI 0.3 to 9.0). Overall, the seropositive prevalence was not different between males and females (5.8% vs. 5.5%). Paradoxically, the seroprevalences were higher in participants without a history of travel to a high-risk area (5.6% vs. 3.9%) and those without a history of close contact to confirmed COVID-19 case (5.7% vs. 4.5%) than their counterparts. The same paradox is also applied to pre-procedural patients. Patients without travel history were likely to have an antibody for SARS-CoV-2 (13.9% vs. 3.2%) and patients without close contact to the case also had more chance to develop an antibody (12.3% vs. 9.1%). However, healthcare workers with travel history had slightly more chance to develop IgM (5.0% vs. 3.7%) and with close contact history (4.1% vs. 3.6%). In general, participants with upper respiratory tract symptoms had a higher chance of being seropositive (9.6% vs. 4.5%), of which dyspnea had the highest (30.0%, 95% CI 16.7 to 47.9). Likewise, pre-procedural patients with dyspnea had the most IgM positive (29.6%, 95% CI 15.9 to 48.5), and healthcare workers with dyspnea (33.3%, 95% CI 6.1 to 79.2). Of 690

participants without present upper respiratory tract symptom, 31 had IgM positive for COVID-19 (4.5%, 95% CI 3.2 to 6.3) which consisted of 20 of 566 healthcare workers (3.5%, 95% CI 2.3 to 5.4) and 11 of 124 patients (8.9%, 95% CI 5.0 to 15.2). History of negative PCR was associated with a surprisingly higher chance of seropositive than those with no PCR test result (6.5% vs. 5.3%) (table 3). Unfortunately, none of the participants with positive IgM had opportunities for PCR testing.

Table 3 Demographic characteristics and seroprevalence in hospital staff and pre-procedural patients

	All Participants		Hospital Staff		Pre-procedural Patients	
	N	IgM+	n	IgM+	n	IgM+
Total	857	47 (5.5%)	675	25 (3.7%)	182	22 (12.1%)
Median age, years (25th–75th percentile)	37 (27–45)		36.5 (28–45)		37 (25–53)	
Male	207 (24.1%)	12 (5.8%)	145(21.5%)	6 (4.1%)	62 (34.1%)	6 (9.7%)
Female	640 (74.7%)	35 (5.5%)	521(77.2%)	19 (3.6%)	119 (65.4%)	16 (13.4%)
Unspecified	10 (1.2%)	0 (0.0%)	9 (1.3%)	0 (0.0%)	1 (0.5%)	0 (0.0%)
Thai	847	47 (5.5%)	671	25 (3.7%)	176	22 (12.5%)
Non-Thai	10	0(0.0%)	4	0 (0.0%)	6	0 (0.0%)
Region						
North	61	1 (1.6%)	59	1 (1.7%)	2	0 (0.0%)
Northeast	269	8 (3.0%)	220	4(1.8%)	49	4 (8.2%)
Central	244	29 (11.9%)	183	12 (6.6%)	61	17 (27.9%)
South	109	2 (1.8%)	88	2 (2.3%)	21	0 (0.0%)
East	174	7 (4.0%)	125	6 (4.8%)	49	1 (2.0%)
History of travel to high risk area						
Yes	51	2 (3.9%)	20	1 (5.0%)	31	1 (3.2%)
No	806	45 (5.6%)	655	24 (3.7%)	151	21 (13.9%)
History of close contact confirmed case						
Yes	132	6(4.5%)	121	5(4.1%)	11	1 (9.1%)
No	725	41 (5.7%)	554	20 (3.6%)	171	21 (12.3%)
Asymptomatic	690	31 (4.5%)	566	20 (3.5%)	124	11 (8.9%)
Symptomatic	167	16 (9.6%)	109	5 (4.6%)	58	11 (19.0%)
Fever	49	7 (14.3%)	17	0 (0.0%)	32	7 (21.9%)
Cough	83	8 (9.6%)	52	1 (1.9%)	31	7 (22.6%)
Rhinitis	64	7 (10.9%)	47	2 (4.3%)	17	5 (29.4%)
Sore throat	55	8 (14.5%)	37	3 (8.1%)	18	5 (27.8%)
Dyspnea	30	9 (30.0%)	3	1 (33.3%)	27	8 (29.6%)
Previous PCR status						
Negative	124	8 (6.5%)	77	1 (1.3%)	47	7 (14.9%)
Never tested	733	39 (5.3%)	598	24 (4.0%)	135	15 (11.1%)

Data were presented in counts and percentages unless otherwise specified.
IgM+, immunoglobulin M positive; NA, not available; PCR, polymerase chain reaction.

COVID-19 prevalence and immunoglobulin M seroprevalence

PCR-confirmed COVID-19 case and population data were acquired for participating provinces. Overall, COVID-19 prevalence was 2.44 cases per 100,000 population. Participating provinces in the Eastern region had the highest prevalence of COVID-19 (6.54 cases per 100,000 population) while provinces in northeastern had the lowest prevalence (supplemental table E2). There was no correlation between IgM seroprevalence, and PCR confirmed COVID-19 prevalence (p=0.199).

Characteristics of immunoglobulin G seropositive participants

IgG was detected in two participants (0.2%, 95% CI 0.1 to 0.8)who also had a positive IgM antibody. In other words, we did not find any participants with isolated positive IgG. Participant A was a Thai female healthcare worker who worked in a community hospital in the Central region of Thailand. She had a sore throat but had no history of travel to a high-risk area or close contact to confirmed COVID-19 case and did not have a PCR test before. Participant B was a Thai female preprocedural patient who visited another community hospital in the Central region. She had no symptom, no history of travel to a high-risk area, or close contact to confirmed COVID-19 case. Participant B had a previously negative PCR result (table 4).

Table 4 Characteristics of Participants who Developed Immunoglobulin G Antibody

	Age Range, years	Gender	Ethnicity	Region	Occupation	History of travel to a high-risk area	History of contact to a confirmed case	Symptoms	Previous PCR status
Participant A	56-60	Female	Thai	Central	HCW	No	No	Sore throat	Never tested
Participant B	41-45	Female	Thai	Central	Patient	No	No	No	Negative

HCW, healthcare worker; PCR, polymerase chain reaction; Age range was used for participant's privacy and confidentiality.

DISCUSSION

COVID-19 seroprevalence in asymptomatic staff and patients in Thai community hospitals was higher than hospitals in China (4.5% vs. 2.5%).[3] Seroprevalence in asymptomatic hospital staff in Thailand was also higher than hospitals in China (3.5% vs. 1.8%)[3] but less than a tertiary hospital in Belgium (3.5% vs. 6.4%).[4] Moreover, seroprevalence in asymptomatic hospital staff in Thailand was less than asymptomatic frontline firefighters/paramedics of the US fire department (3.5% vs 7.7%).[5] Asymptomatic patients in Thailand seemed to have higher seroprevalence than China (8.9% vs.3.5%).[3] Unlike China and Belgium where the seroprevalences were mostly from positive IgG, our study revealed mostly positive IgM. Comparison with Belgium hospital should be interpreted with caution due to the unknown PCR status of Belgium subjects.

People with a history of travel to a high-risk area or close contact to confirmed COVID-19 case turned out to have a low COVID-19 seroprevalence in our study. One possible explanation could be the successful implementation of the national PCR-based screening policy, low barrier to medical care under the Universal Coverage scheme as well as disease awareness and health literacy of the Thais. People with those predefined risks might have already sought medical attention; several cases might have been identified with the PCR test and were

either quarantined or sent to proper care. The remaining eligible individuals might be dominated by those without predefined risks.

To prevent nosocomial spread in a community hospital or primary hospital setting, hospital staff should be tested for COVID-19 before working their routine and should repeat the test at a specified period. Antibody testing was less uncomfortable than PCR testing which might lead to more compliance when hospital staff was planned to get multiple tests. False-negative could occur in any test. High sensitivity testing was encouraged for the high-risk population including hospital staff to reduce false negative.[1] Negative result on PCR with negative antibody test or IgG positive only might be acceptable for hospital staff starting the work when such a highly sensitive test was not completely developed. To help prevent community spread in an aspect of a community hospital setting, patients who visited the hospital with any chief complain should be tested with rapid antibody testing to screen some potential spreader and prevent them from returning to the community during spreadable period especially when PCR testing was not readily available in a remote area.

Serological testing provides some crucial epidemiological information and would have been more effective when combined with other diagnostic tests such as PCR. While all participants with positive results from the free-of-charge rapid IgM/IgG test provided in this study were encouraged to get PCR testing, a majority of community hospitals still did not have access to the PCR testing because of both financial and non-financial reasons. Recommendation for PCR testing after positive rapid IgM/IgG test was not fully complied so we did not have information about the participants with positive IgM. However, with the immunoglobulin status and PCR results, we can shape the situation more accurately for both individual and regional views. Hopefully, with this and other vigorous and dedicated studies on antibody status around the globe, serology testing would provide useful information for pandemic control.

The relatively predominant positive IgM status compared to positive IgG might relate to the exclusion criteria of our observational study as all confirmed COVID-19 cases were already excluded according to the national protocol. Given the fact that IgM represents an acute infection while IgG is suggestive of past infection, excluding COVID-19 confirmed cases who had a higher chance of developing IgG during the study period would underestimate the actual IgG seroprevalence and underestimate the actual proportion of seropositive participants who had previous PCR testing. While this might be considered a limitation of our study as compared to other studies

that did not exclude COVID-19 confirmed cases, our observation reflected a real picture of seroprevalence in a country with low COVID-19 incidence and mortality. We did not have a chance to perform the serological test among the COVID-19 confirmed cases as the mild case had to get quarantined and the moderate and severe ones were referred to a higher level of care. Also, we could not perform multiple serological tests at different time points as doing so was not approved by the ethics committee.

Only 2 out of 47 IgM positive participants also had IgG positive and none of IgM positive participants got subsequent PCR test after IgM positive status. There was a possibility that IgM positive might be false positive. However, the false-positive rate for IgM or IgG was 2% according to internal validation of test kit while IgM positive seroprevalence was 5.5%. While the false positive of IgM might occur due to imperfection of test kit and no confirmation with PCR test after positive antibody against COVID-19 which might lead to overestimation of actual IgM seroprevalence, this limitation shaped the real-world situation in the early phase of pandemic awareness in a community hospital setting where more advanced test methods were not readily available.

CONCLUSIONS

COVID-19 antibody test could detect a substantial number of potential silent spreaders in Thai community hospitals. Antibody testing should be encouraged for mass screening, especially in asymptomatic individuals.

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Contributors TN conceptualized the study, design methodology, administrated the project, contributed to data curation and clinical investigation, validate the data, performed formal analysis and provided software, visualized the data, and wrote the original draft of the manuscript. KP conceptualized the study, design methodology, administrated the project, contributed to data curation and clinical investigation, validate the data, performed formal analysis and provided software, provided resources for the study, supervised the study, and wrote the original draft of the manuscript. KC contributed to data curation and clinical investigation, and validate the data. NH conceptualized the study, design methodology, administrated the project, provided resources for the study, and supervised the study. All authors reviewed, edited the final manuscript, agreed to be held accountable for all aspects of the work related to its accuracy and integrity.

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Competing Interests None declared.

Patient and public involvement Patient 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 required.

Ethics approval Ethics approval was obtained from the Institutional Review Board of Chulalongkorn University (IRB No.236/63), Ethics Committee of National Cancer Institute Thailand (EC No.015/2563), Research Ethics Committee of Nan Hospital (REC No.063/2563), Ethics Committee of Chaophraya Yommarat Hospital (YM No.013/2563), Institutional Review Board of Songkhla Hospital (IRB No.2020-Md-J3-04001), Ethics Committee of Lampang Hospital (EC No.26/63), Ethics Committee of Sikhio Hospital (SK No.2020/001), Ethics Committee of Samut Sakhon Hospital, Research Ethics Committee of Prapokklao Hospital (CTIREC No.030/63), Institutional Review Board of Burapha University (HS No.027/2563), Ethics Committee of Srinakharinwirot University (SWUEC No. 119/2563F), Institutional Review Board of Phaholpolpayuhasena Hospital (IRB No.2020-04), Institutional Review Board of Samitivej Sukhumvit Hospital (IRB No.001/2563), Research Ethics Committee of Pattani Provincial Public Health Office (RECPTN No.015/63), Institutional Review Board of Bangplee Hospital (IRB No.1/2563), Institutional Review Board of Chonburi Hospital (IRB No.08/2563), Institutional Review Board

of Surin Hospital (IRB No.15/2563), Institutional Review Board of Child and Adolescent Mental Health Rajanagarindra Institute (IRB No.2563/005) and Institutional Review Board of Sukhothai Hospital (IRB No.44/2563). Given no ethics committees available in the participating community hospitals, participation in this study was approved by the hospital directors or representatives. All participants provided written informed consent including consent for publication of raw data. (Thai Clinical Trials Registry: TCTR20200426002)

Data availability statement All data relevant to the study are included in the article; the anonymized dataset is available upon requested by emailing doctorkrit@gmail.com

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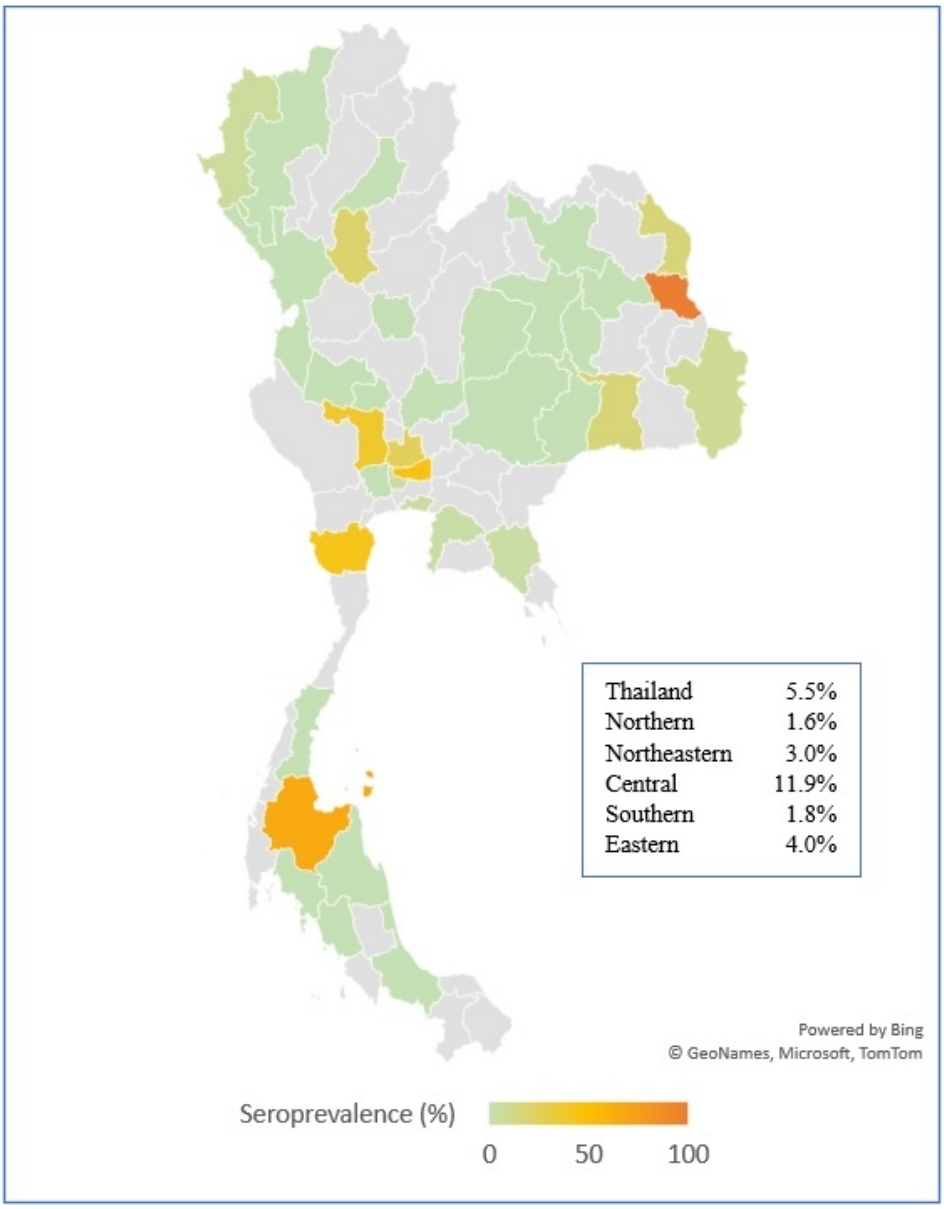

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COVID-19 Antibody in Thai Community Hospitals

SUPPLEMENTARY FILES

Supplemental Table E1 Geographical distribution of 52 participating community hospitals

	Participating Provinces	Total Provinces	Population of Participating Provinces	Population of All Provinces
Thailand*	35 (46.1%)	76	35,416,545 (58.2%)	60,892,671
Northern	3 (33.3%)	9	2,505,118 (39.4%)	6,350,499
Northeastern	11 (55.0%)	20	15,064,919 (68.4%)	22,014,248
Central*	13 (50.0%)	26	10,053,397 (55.3%)	18,192,361
Southern	6 (42.9%)	14	5,697,112 (60.0%)	9,493,757
Eastern	2 (28.6%)	7	2,095,999 (43.3%)	4,841,806

* Not include Bangkok which has no community hospital.
Data were presented in counts and percentages.

Supplemental Table E2 Number and prevalence of PCR confirmed COVID-19 cases in participating provinces

	PCR Confirmed COVID-19 Cases	Population	PCR Confirmed COVID-19 Prevalence per 100,000 Population
Overall	864	35,416,545	2.44
Northern	47	2,505,118	1.88
Chiang Mai	41	1,779,254	2.30
Mae Hong Son	5	284,138	1.76
Phrae	1	441,726	0.23
Northeastern	85	15,064,919	0.56
Buriram	13	1,595,747	0.81
Chaiyaphum	3	1,137,357	0.26
Kalasin	3	983,418	0.31
Khon Kaen	6	1,802,872	0.33
Maha Sarakham	1	962,665	0.10
Mukdahan	4	353,174	1.13
Nakhon Phanom	2	719,136	0.28
Nakhon	19	2,648,927	0.72
Ratchasima			
Surin	9	1,396,831	0.64
Ubon Ratchathani	15	1,878,146	0.80
Udon Thani	10	1,586,646	0.63
Central	383	10,053,397	3.81
Ayutthaya	4	820,188	0.49
Chainat	0	326,611	0.00
Lopburi	2	755,556	0.26
Nakhon Pathom	22	920,030	2.39
Nonthaburi	158	1,265,387	12.49
Pathum Thani	39	1,163,604	3.35
Phetchaburi	2	485,191	0.41
Phichit	0	536,311	0.00
Samut Prakan	143	1,344,875	10.63
Sukhothai	3	595,072	0.50
Suphanburi	6	846,334	0.71
Tak	3	665,620	0.45
Uthaithani	1	328,618	0.30
Southern	212	5,697,112	3.72
Chumphon	21	511,304	4.11
Krabi	20	476,739	4.20
Nakhon Si	12	1,561,927	0.77
Thammarat			
Songkhla	134	1,435,968	9.33
Surat Thani	18	1,068,010	1.69
Trang	7	643,164	1.09
Eastern	137	2,095,999	6.54
Chanthaburi	3	537,698	0.56
Chonburi	134	1,558,301	8.60

PCR, polymerase chain reaction.

Hospital	No	Gender	Age	Travel to Hi	Close conta	Healthcare	Thai	Previous PC
Hospital1	1	0	49	0	0	1	1	0
	2	0	55	0	0	1	1	0
	3	0	53	0	0	1	1	0
	4	0	40	0	1	0	1	0
	5	1	40	0	1	1	1	0
	7	0	42	0	0	1	1	0
	8	0	44	0	0	0	1	0
	9	0	33	0	0	0	1	0
	10	0	29	0	0	0	1	0
	11	1	34	0	1	1	1	0
	12	1	30	0	0	0	1	0
	13	0	42	0	0	1	1	0
	14	0	26	0	1	1	1	0
	15	0	24	0	0	0	1	0
	16	0	24	0	0	0	1	0
	17	0	29	0	1	1	1	0
	18	0	36	0	0	1	1	0
	19	0	53	0	0	0	1	0
	20	0	48	0	0	1	1	0
	21	0	26	0	1	1	1	0
	22	0	33	0	1	1	1	0
Hospital2	1	0	32	0	0	1	1	1
	2	0	26	0	0	1	1	1
	3	0	35	0	0	1	1	1
	4	0	45	0	0	1	1	1
	5	0	43	0	0	1	1	1
	6	0	34	0	0	1	1	0
	7	0	22	0	0	1	1	0
	8	0	36	0	0	1	1	0
	9	0	31	0	0	1	1	0
	10	0	39	0	0	1	1	0
	11	0	42	0	0	1	1	0
	12	0	40	0	0	1	1	0
	13	0	35	0	0	0	1	0
	14	0	50	0	0	1	1	0
	15	1	27	0	0	1	1	0
	16	0	31	0	0	1	1	0
	17	1	36	0	0	1	1	0
	18	0	25	0	0	1	1	0
	19	0	32	0	1	1	1	0
	20	0	26	0	0	1	1	0
	21	0	40	0	0	1	1	0
	22	0	37	0	0	1	1	0
	24	0	51	0	0	1	1	0
	25	0	47	0	0	1	1	0
	26	0	45	0	0	1	1	0
	27	1	29	0	0	1	1	0
	28	0	40	0	0	1	1	0
	29	0	34	0	0	1	1	0
	30	0	36	0	0	0	1	0
	31	0	52	0	0	1	1	0

	32	0	28	0	0	1	1	0
	33	1	27	0	0	1	1	0
	34	0	30	0	0	1	1	0
	35	0	25	0	0	1	1	0
	36	0	41	0	0	1	1	0
	37	0	40	0	0	1	1	0
	38	0	47	0	0	1	1	0
	39	0	29	0	0	1	1	0
	40	0	37	0	0	0	1	0
Hospital3	1	1	45	0	0	1	1	0
	2	0	26	0	0	1	1	0
	3	0	53	0	0	1	1	0
	4	0	26	0	0	1	1	0
	5	0	48	0	0	1	1	0
	6	0	44	0	0	1	1	0
	7	0	44	0	0	1	1	0
	8	0	32	0	0	1	1	0
	9	0	31	0	0	1	1	0
	10	0	41	1	0	1	1	0
	11	0	38	0	0	1	1	0
	12	0	32	0	0	1	1	0
	13			0	0	1	1	0
	14	0	25	0	0	1	1	0
	15	0	45	0	0	1	1	0
	16	0	31	0	0	1	1	0
	17	1	20	0	0	1	1	0
	18	0	46	0	0	1	1	0
	19	0	23	0	0	1	1	0
	20	0	24	0	0	1	1	0
	21	1	26	0	0	1	1	0
	22	0	26	0	0	1	1	0
	23	0	39	0	0	1	1	0
	24	0	24	0	0	1	1	0
	25	0	45	0	0	1	1	0
	26	0	41	0	0	1	1	0
	27	0	41	0	0	1	1	0
	28	0	24	0	0	1	1	0
	29	0	48	0	0	1	1	0
	30	0	44	0	0	1	1	0
	31			0	0	1	1	0
	32	0	28	0	0	1	1	0
	33	1	21	0	0	1	1	0
	34	0	44	0	1	1	1	0
	35	0	40	0	1	1	1	0
	36	0	45	0	0	1	1	0
	37	0	41	0	0	1	1	0
	38	1	60	0	0	1	1	0
	39	0	21	0	0	1	1	0
	40	0	38	0	0	1	1	0
a1		0	46	0	0	1	1	0
a2		0	55	0	0	1	1	0
a3		0	35	0	0	1	1	0

	a4		0	25	0	0	1	1	0
	a5		0	55	0	0	1	1	0
	a6		0	41	0	0	1	1	0
	a7		0	45	0	0	1	1	0
	a8		0	25	0	0	1	1	0
	a9		0	45	0	1	1	0	0
	a10		0		0	0	1	1	0
	a11		0	36	0	0	1	1	0
	a12		0	35	0	0	1	1	0
	a13		1	22	0	0	1	1	0
	a14		0	32	0	0	1	1	0
	a16		0	41	0	0	1	1	0
	a17		1	38	0	0	1	1	0
	a18		1	32	0	0	1	1	0
	a19		1	29	0	0	1	1	0
	a20		0	43	0	0	1	1	0
	a21		0	39	0	0	1	1	0
	a22		0	33	0	0	1	1	0
	a24		1	26	0	0	1	1	0
	a25		0	28	0	0	1	1	0
	a26		0	29	0	0	1	1	0
	a29		0	57	0	0	1	1	0
	a32		0	29	0	0	1	1	0
	a34		0	34	0	0	1	1	0
	a35		0	25	0	0	1	1	0
	a37		0	39	0	0	1	1	0
	a38		0	28	0	0	1	1	0
	a39		1	21	0	0	1	1	0
	a43		0	38	0	0	1	1	0
Hospital4		0	0	66	1	0	0	1	0
		2	0	33	1	0	0	1	0
		5	1	29	0	0	0	1	0
Hospital5		1	1	26	0	0	0	1	0
		2	0	21	0	0	0	1	0
		3	1	35	0	0	0	1	0
		4	0	37	0	0	0	1	0
		5	0	20	0	0	0	1	0
		6	0	16	0	0	0	1	0
		7	0	38	0	0	0	0	0
		8	0	2	0	0	0	1	0
		9	1	44	0	0	0	1	0
		10	0	39	0	0	0	1	0
		11	1	24	0	0	0	1	0
		12	0	18	0	0	0	1	0
		13	0	24	0	0	0	1	0
		14	1	1	0	0	0	1	0
		15	1	25	0	0	0	1	0
		16	0	25	0	0	0	0	0
		17	0	19	0	0	0	1	0
		18	1	21	0	0	0	1	0
		19	0	21	0	0	0	1	0
		20	1	22	0	0	0	1	0

	21	0	22	0	0	0	1	0
	22	1	68	0	0	0	1	0
	23	0	95	0	0	0	1	0
	24	0	73	0	0	0	1	0
	25	1	57	0	0	0	1	0
	26	0	86	0	0	0	1	0
	27	1	74	0	0	0	1	0
	28	0	60	0	0	0	1	0
	29	1	76	0	0	0	1	0
	30	1	19	0	0	0	1	0
	31	0	31	0	0	0	1	0
	32	1	83	0	0	0	1	0
	33	0	81	0	0	0	1	0
	34	1	50	0	0	0	1	0
	35	0	78	0	0	0	1	0
	36	1	56	0	0	0	1	0
	37	0	46	0	0	0	1	0
	38	0	54	0	0	0	1	0
	39	1	70	0	0	0	1	0
	40	1	56	0	0	0	1	0
Hospital6	0	1	57	0	0	0	1	0
	2	0	51	0	0	0	1	0
Hospital7	1	1	48	0	0	1	1	0
	2	0	26	0	0	1	1	0
	3	1	26	0	0	1	1	0
	4	0	50	0	0	1	1	0
	5	1	30	0	1	0	1	1
	6	1	67	0	1	0	1	1
	7	1	25	0	1	0	1	1
	9	0	30	0	1	1	1	0
	10	0	35	0	1	1	1	0
	11	0	46	0	0	1	1	0
	12	0	51	0	0	1	1	0
	13	0	44	0	0	1	1	0
	14	0	33	0	0	0	1	0
	15	0	32	0	0	1	1	1
	16	0	45	0	0	1	1	0
	17	0	31	0	0	1	1	1
	18	0	34	0	0	1	1	1
	19	0	42	0	0	1	1	0
	20	0	26	0	0	1	1	1
	21	1	25	0	0	1	1	0
	22	0	26	0	0	1	1	0
	23	0	35	0	0	1	1	0
	24	0	30	0	0	1	1	0
	25	0	32	0	0	1	1	0
	26	0	26	0	0	1	1	0
	27	0	29	0	0	1	1	0
	28	0	35	0	0	1	1	0
	29	1	26	0	0	1	1	0
	30	0	31	0	0	1	1	0
	31	0	21	0	0	1	1	0

	32	0	39	1	1	0	1	1
	33	0	25	0	0	1	1	0
	34	0	32	0	0	1	1	0
	35	1	24	0	0	1	1	0
	36	0	33	0	0	1	1	0
	37	0	32	0	0	1	1	0
	38	0	27	0	1	1	1	0
	39	0	26	0	0	1	1	0
	40	0	28	0	0	1	1	0
Hospital8	1	0	51	0	0	1	1	0
	2	0	23	0	0	1	1	0
	3		27	0	0	1	1	0
	4		29	0	0	1	1	0
	5		42	0	0	1	1	0
	6	0	48	0	0	1	1	0
	7	0	31	0	0	1	1	0
	8	0	23	0	0	1	1	0
	9	0		0	0	1	1	0
	10			0	0	1	1	0
	11	0	51	0	0	1	1	0
	12	0	48	0	0	1	1	0
	13	0	26	0	0	1	1	0
	14	0	46	0	0	1	1	0
	15	1	37	0	0	1	1	0
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	17	1	41	0	0	1	1	0
	18	0	28	0	0	1	1	0
	19	0	34	0	0	1	1	0
	20	0	56	0	0	1	1	0
	21	1	56	0	0	1	1	0
	22	0	28	0	1	1	1	0
	23	0	30	0	0	1	1	0
	24	1	26	0	0	1	1	0
	25	1	36	0	0	1	1	0
	26	0	27	0	0	1	1	0
	27	1	27	0	0	1	1	0
	28	1		0	0	1	1	0
	29	0	53	0	0	1	1	0
	30	0	48	0	0	1	1	0
	31	0	47	0	0	1	1	0
	32	0		0	0	1	1	0
	33	0	31	0	0	1	1	0
	34	0	31	0	1	1	0	0
	35	0	37	0	0	1	1	0
	36	0	50	0	1	1	1	0
	37		24	0	1	1	1	0
	38	0	30	0	1	1	1	0
	39	0	49	0	0	1	1	0
	40	0	36	0	0	1	1	0
Hospital9	1	1	27	0	1	1	1	0
	2	0	44	0	1	1	1	0
	3	1	29	0	1	1	1	0

	4	0	44	0	0	1	1	0
	5	1	56	1	1	1	1	0
	6	0	62	0	0	0	1	0
	7	1	32	0	0	0	1	0
Hospital10	1	0	23	0	0	1	1	0
	2	0	26	0	1	1	1	0
	3	0	51	0	1	1	1	0
	4	0	29	0	0	1	1	0
	5	0	45	0	0	1	1	0
	6	0	44	0	1	1	1	0
	7	0	29	0	1	1	1	0
	8	0	28	0	1	1	1	0
	9	0	50	0	0	0	1	0
	10	1	38	0	1	1	1	0
	11	0	39	0	1	1	1	0
	12	0	28	0	1	1	1	0
	13		21	0	1	1	1	0
	14	0	24	0	1	1	1	0
	15	0	38	0	1	1	1	0
	16	1	28	0	1	1	1	0
	17	0	55	0	1	1	1	0
	18	0	39	0	0	1	1	0
	19	0	48	0	0	1	1	0
	20	0	42	0	0	1	1	0
	21	0	33	0	0	1	1	0
	22	1	48	0	0	1	1	0
	23	0	39	0	0	1	1	0
	24	1	29	0	0	1	1	0
	25	0	25	0	0	1	1	0
	26	1	31	0	0	1	1	0
	27	1	56	0	0	1	1	0
	28	0	22	0	0	1	1	0
	29			0	0	0	0	0
	30	0	60	0	0	0	1	0
	31	0	25	0	0	0	1	0
	32	0	23	0	0	0	1	0
	33	1	23	0	0	0	1	0
	34	0	53	0	0	0	1	0
	35	0	54	0	0	0	1	0
Hospital11	1	1	53	0	0	1	1	0
	2	0	36	0	0	1	1	0
	3	0	22	0	1	1	1	0
	4	0	39	0	0	1	1	0
	5	1	36	0	0	1	1	0
	6	0	53	0	0	1	1	0
	7	0	42	0	1	1	1	0
	8	0	25	0	0	1	1	0
	9	0	34	0	1	1	1	1
	10	1	36	0	0	1	1	0
	11	1	40	0	0	1	1	0
	12	1	59	0	0	1	1	0
	13	0	26	0	0	1	1	0

	14	0	40	0	0	1	1	0
	15	0	51	0	0	1	1	0
	16	0	43	0	0	1	1	0
	17	0	41	0	0	1	1	0
	18	0	47	0	0	1	1	0
Hospital12	1	0	29	0	0	1	1	0
Hospital13	1	0	41	0	0	1	1	0
	2	0	42	0	1	1	1	0
	3	1	26	0	1	1	1	0
	4	1		0	1	1	1	0
	5	0	45	1	0	1	1	0
	6	0	56	0	1	1	1	0
	7	0		0	1	1	1	0
	8	0	53	0	1	1	1	0
	9	0	44	0	1	1	1	0
	10	0	48	0	1	1	1	0
	11	0	38	0	1	1	1	0
	12	0	57	0	1	1	1	0
	13	1	25	1	0	0	1	1
	14	1	26	0	0	1	1	1
Hospital14	0	1	66	0	0	0	1	0
	1	0	60	0	0	1	1	0
	2		38	1	1	1	1	0
	3	0	39	0	0	1	1	0
	4	0	17	0	0	0	1	0
	5	0	18	0	1	0	1	0
	6	0	30	0	0	1	1	0
	7	0	42	0	0	1	1	0
	8	1	58	1	0	0	1	1
	9	1	60	1	0	0	1	0
	10	1	39	0	0	1	1	0
	11	0	38	1	0	1	1	0
	12	0	15	0	0	0	1	0
	13	0	49	0	0	0	1	0
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	15	1	43	0	0	1	1	0
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	20	0	30	0	0	1	1	0
	21	1	28	0	0	1	1	0
	22	0	28	0	0	1	1	0
	23	0	43	0	1	1	1	0
	24	1	63	0	0	0	1	0
	25	0	31	0	0	1	1	1
	26	0	42	0	0	1	1	0
	27	0	44	0	0	1	1	0
	28	0	26	0	0	1	1	0
Hospital15	1	1	27	0	0	1	1	0
	2	0	42	0	0	1	1	0
	3	0	41	0	0	1	1	0

	4	0	31	0	0	1	1	0
	5	0	31	0	0	1	1	0
	6	1	32	0	0	1	1	0
	7	0	24	0	0	1	1	0
	8	0	43	0	0	0	1	0
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	10	0	27	0	0	1	1	0
	11	0	33	0	0	0	1	0
	12	1	56	0	0	1	1	0
	13	0	26	0	0	1	1	0
	14	1	21	0	0	1	1	0
	15	0	35	0	0	1	1	0
	16	1	49	0	0	0	1	0
	17	0	43	0	0	1	1	0
	18	0	34	0	0	1	1	0
	19	0	26	1	0	0	1	0
	20	0	31	0	0	1	1	0
	21	0	33	0	0	1	1	0
	22	0	30	0	0	1	1	0
	23	1	42	0	0	0	1	0
	24	0	28	0	0	1	1	0
	25	0	46	0	0	1	1	0
	26	0	33	0	0	1	1	0
	27	0	31	0	0	1	1	0
	28	0	44	0	0	0	1	0
	29	0	44	0	0	1	1	0
	30	0	30	0	0	1	1	0
	31	0	35	0	0	1	1	0
	33	1	31	0	0	1	1	1
	34	0	30	0	0	1	1	0
	35	0	25	0	0	1	1	0
	36	1	28	1	0	1	1	0
	37	0		0	0	1	1	0
Hospital16	1	0	40	0	1	1	1	1
	2	1	34	0	1	1	1	1
	3	0	37	0	1	1	1	1
	4	0	31	0	1	1	1	1
	5	0	44	0	1	1	1	1
	6	1	37	0	1	1	1	1
	7	1	22	0	1	1	1	1
	8	0	36	0	1	1	1	1
	9	1	40	0	1	1	1	1
	10	0	40	0	1	1	1	1
	11	0	45	0	1	1	1	1
	12	0	28	0	1	1	1	1
	13	1	27	0	1	1	1	1
	14	0	56	0	1	1	1	1
	15	0	49	0	1	1	1	1
	16	0	41	0	1	1	1	0
	17	1	32	0	1	1	1	1
	18	0	29	0	1	1	1	1
	19	0	47	0	1	1	1	1

	20	0	29	0	1	1	1	1
Hospital17	1	0	49	0	1	1	1	0
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	3	0	49	0	0	0	1	0
	4	0	28	1	0	1	1	0
	5	0	24	0	0	1	1	0
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	7	0	30	0	0	1	1	0
	8	0	28	0	0	1	1	1
	9	0	31	0	0	0	1	0
	10	0	31	0	0	1	1	0
	11	0	31	0	0	0	1	0
	12	0	37	0	1	1	1	0
	13	0	27	0	1	1	1	0
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	15	0	33	0	0	1	1	0
	16	1	53	0	1	1	1	0
	17	0	54	0	0	1	1	0
	18	1	58	0	0	1	1	0
	19	0	41	0	0	0	1	0
	20	0	39	0	0	0	1	0
	21	0	23	0	0	0	1	0
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	23	0	46	0	0	0	1	0
	24	1	27	0	1	1	1	0
	25	1	27	0	0	1	1	0
	26	0	48	0	0	1	1	0
Hospital18	2	0	26	0	0	1	1	0
	3	0	52	0	0	1	1	0
	4	0	41	0	0	1	1	0
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	9	0	40	0	0	1	1	0
	10	0	48	0	0	1	1	0
	11	0	52	0	0	1	1	0
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	13	1	40	0	0	1	1	0
	14	0	24	0	0	1	1	0
	15	0	40	0	0	1	1	0
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	17	0	37	0	0	0	1	0
	18	0	53	0	0	0	1	0
	19	0	57	0	0	1	1	0
	20	0	55	0	0	1	1	0
Hospital19	1	0	80	0	0	0	1	1
	2	1	30	0	0	0	1	1
	3	1	30	1	0	0	1	1
	4	1	47	1	0	0	1	1
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	6	1	77	0	0	0	1	1

	7	1	24	1	0	0	1	1
	8	1	35	1	0	0	1	1
	9	1	31	1	0	0	1	1
	10	1	37	1	0	0	1	1
	11	0	60	1	0	0	1	1
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	17	0	3	1	0	0	1	1
	18	0	81	1	0	0	1	1
	19	1	19	0	0	0	1	1
	20	0	61	0	0	0	1	1
Hospital20	1	0	57	0	0	1	1	0
	2	1	38	0	0	1	1	0
	3	1	56	0	0	1	1	0
	4	0	56	0	0	1	1	0
	5	0	42	0	0	1	1	0
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	8	0	57	0	0	1	1	0
	9	0	53	0	0	1	1	0
Hospital21	1	0	18	0	0	0	1	0
	2	0		1	0	0	1	0
	3	0	28	1	0	0	1	0
Hospital22	1	0	59	0	0	0	1	0
	2	1	72	0	0	0	1	0
	3	1	70	0	0	0	1	0
	4	0	10	0	0	0	1	1
	5	0	66	0	0	0	1	0
Hospital23	1	0	28	0	0	1	1	0
	2	0	22	0	0	1	1	0
	3	1	41	0	0	1	1	0
	4	0	34	0	0	1	1	0
	5	0	29	0	0	1	1	0
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	10	0	38	0	0	1	1	0
	11	1	39	0	0	1	1	0
	12	0	48	0	0	0	1	0
	13	0	31	0	0	1	1	0
	14	0	44	0	0	0	1	0
	15	0	40	0	0	0	1	0
	16	0	37	0	0	0	1	0
	17	0	24	0	0	1	1	0
	18	0	25	0	0	1	1	0
	19	1		0	0	1	1	0
	20	1	44	0	0	0	1	0
Hospital24	1	1	54	0	0	0	1	0

	2	1	57	0	0	1	1	1
	3	0	45	0	0	1	1	0
	4	0	52	0	0	1	1	0
	5	0	37	0	0	1	1	0
	6	0	44	0	0	1	1	0
	7	0	23	0	1	1	1	0
	8	0	23	0	1	0	1	0
	9	1	40	0	0	1	1	0
	10	0		0	0	1	1	0
	11	0	53	0	1	1	1	0
	12	0	43	0	1	1	1	0
	13	0	29	0	1	1	1	0
	14	0	25	0	1	1	1	0
	15	0	25	0	1	1	1	0
	16	1	38	0	1	1	1	0
	17	0	55	0	1	1	1	0
	18	0	59	0	0	1	1	0
	19	0	52	0	0	1	1	0
	20	1	23	0	0	1	1	0
Hospital25	1	0	44	0	0	1	1	0
	2	0	37	0	1	1	1	1
	3	0	42	0	1	1	1	1
	4	0	47	0	1	1	1	1
	5	1	42	0	1	1	1	1
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	17	0	23	0	0	1	1	1
	18	0	43	0	1	1	1	1
	19	1	54	0	0	0	1	0
Hospital26	1	1	45	0	0	1	1	0
	2	0	48	0	0	1	1	0
	3	0	56	0	0	1	1	0
	4	0	45	0	0	1	1	0
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	10	0	25	0	0	1	1	0
	11	0	22	0	0	1	1	0
	12	0	29	0	0	1	1	0
	13	0	40	0	0	1	1	0
	14	0	42	0	0	1	1	0

	15	0	40	0	0	1	1	0
	16	1	46	0	0	1	1	0
	17	1	35	0	0	1	1	0
	18	1	41	0	0	1	1	0
	19	0	38	0	0	1	1	0
	20	1	56	0	0	1	1	0
Hospital27	1	1	25	0	0	0	1	0
Hospital28	1	0	26	0	0	1	1	0
	2	1	27	0	0	1	1	0
	3	1	25	0	0	1	1	0
	4	0	27	0	0	1	1	0
	5	1	47	0	0	1	1	0
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	15	0	51	0	0	1	1	0
	17	1	42	0	1	1	1	0
	18	0	33	0	0	1	1	0
	19	0	44	0	0	1	1	0
	20	1	35	0	0	1	1	0
Hospital29	1	0	36	0	0	1	1	0
	2	0	40	0	0	1	1	0
	3	0		0	0	1	1	0
	4	0	59	0	0	1	1	0
	5	0	42	0	0	1	1	0
	6	0	26	0	0	1	1	0
	7	0	28	1	0	1	1	0
	8	0	24	0	0	1	1	0
Hospital30	1	0	19	1	0	0	1	1
	2	0	27	0	0	1	1	1
	3	0	26	0	0	1	1	0
	4	0	25	0	0	1	1	0
	5	1	26	0	0	1	1	0
	6	1	25	1	0	1	1	1
	7	0	25	0	0	1	1	0
	8	0	50	0	0	1	1	0
	9	1	59	0	0	1	1	0
	10	1	40	0	0	1	1	0
	11	1	37	0	0	1	1	0
	12	0	25	0	0	1	1	0
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	14	1	53	0	0	1	1	0
	15	0	45	0	0	1	1	0
Hospital31	1	0	33	0	0	1	1	0
	2	1	31	0	0	1	1	0
	3	0	24	0	0	1	1	0

	5	0	53	0	0	1	1	0
	6	0	42	0	1	1	0	1
	7	0	23	0	0	1	1	0
	8	0	53	0	0	1	1	0
	9	1	34	0	0	1	1	0
	10	0	23	0	0	0	1	0
	11	0	38	0	1	1	1	0
	12	1	26	0	0	1	1	0
	13	0	46	0	0	1	1	0
	14	0	29	0	0	1	1	0
	15	0	26	0	0	1	1	0
	16	0	27	0	0	1	1	0
	17	0	45	0	1	1	1	0
	19	0	25	0	0	1	1	0
	20	0	59	0	0	1	1	0
	21	0	46	0	1	1	1	0
	22	0	38	0	1	1	1	0
Hospital32	1	0	30	0	0	1	1	1
	2	0	28	0	0	0	1	0
	3	0	38	0	0	1	1	0
	4	0	40	0	0	1	1	0
	5	0	32	0	0	1	1	0
	6	0	33	0	0	1	1	0
	7	0	36	0	0	1	1	0
	8	0	27	0	0	1	1	0
	9	0	27	0	0	1	1	0
	10	1	39	0	0	1	1	0
	11	0	33	0	0	1	1	0
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	17	0	46	0	0	1	1	0
	18	0	37	0	0	1	1	0
	19	0	46	0	0	1	1	0
	20	0	31	0	0	1	1	0
Hospital33	1	0	28	0	0	1	1	0
	2	1	34	0	0	1	1	0
	3	0	22	0	0	1	1	0
	4	0	40	0	0	1	1	0
	5	1	50	0	0	1	1	0
	6	0	58	0	0	1	1	0
	7	0	44	0	0	1	1	0
	8	0	51	0	0	1	1	0
	9	0	27	0	0	1	1	0
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	11	0	24	0	0	1	1	0
	12	0	46	0	0	1	1	0
	13	1	52	0	0	1	1	0
	14	0	32	0	0	1	1	0
	15	0	43	0	0	1	1	0

	16	0	27	0	0	1	1	0
	17	0	34	0	0	1	1	0
	18	1	37	0	0	1	1	0
	19	1	26	0	0	1	1	0
	20	1	43	0	0	1	1	0
Hospital34	1	1	26	0	1	1	1	0
	2	1	45	0	0	0	1	0
	3	0	45	0	0	0	1	0
	4	0	23	0	1	1	1	0
	5	0	26	0	0	1	1	0
	6	0	24	0	0	1	1	0
	7	0	39	1	0	1	1	0
	8	0	23	0	0	1	1	0
	9	0	26	1	0	1	1	0
	10	0	31	0	0	1	1	0
	11	0	22	1	0	1	1	0
Hospital35	1	0	43	0	0	1	1	0
	2	0	45	0	0	1	1	0
	3	0	37	0	0	1	1	0
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	5	0	46	0	0	1	1	0
	6	0	28	0	0	1	1	0
	7	0	25	0	0	1	1	0
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	9	1	50	0	0	1	1	0
	10	0	36	0	0	1	1	0
	11	0	43	0	0	1	1	0
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	17	1	59	0	0	1	1	0
	18	1	35	0	0	1	1	0
	19	0	41	0	0	1	1	0
	20	0	34	0	0	1	1	0
Hospital36	1	0	51	0	0	1	1	1
	2	0	55	0	0	1	1	1
	3	0	55	0	0	1	1	1
	4	0	42	0	0	1	1	1
	5	0	40	0	0	1	1	1
	6	1	43	0	0	1	1	1
	7	0	43	0	0	1	1	1
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	9	0	54	0	0	1	1	1
	10	0	47	0	0	1	1	1
	11	1	40	0	0	1	1	1
	12	1	56	0	0	1	1	1
	13	1	53	0	0	1	1	0
	14	0	51	0	0	1	1	1
	15	1	38	0	0	1	1	1
	16	0	23	0	0	1	1	1

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	19	0	33	0	0	1	1	1
	20	0	35	0	0	1	1	0
Hospital37	1	1	51	0	1	1	1	0
	2	1	45	1	1	1	1	0
	3	0	28	0	1	1	1	0
	4	0		0	0	1	1	0
	5	0	36	0	0	1	1	0
	6	0	41	0	0	1	1	0
	7	0	45	0	0	0	1	0
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	11	0	23	0	0	0	1	0
	12	0	24	0	1	1	1	0
	13	0	22	0	1	1	1	0
	14	0	23	1	1	1	1	0
	15	1	44	0	0	1	1	1
Hospital38	1	1	26	1	0	1	1	1
	2	0	25	1	1	1	1	0
	3	1	54	0	1	1	1	0
	5	0	54	0	0	1	1	0
	6	0	39	0	0	1	1	0
	7	0	55	0	0	1	1	0
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	16	1	52	0	0	1	1	0
	17	0	54	0	0	1	1	1
	18	1	52	0	0	1	1	0
	19	0	24	0	0	1	1	1
	20	0	57	0	0	1	1	0
Hospital39	1	1	53	0	0	1	1	0
	2	1	41	0	0	1	1	0
	3	1	32	0	0	1	1	0
	5	1	31	0	0	1	1	0
	7	0	57	0	0	1	1	0
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	12	0	27	0	0	0	1	0
	13	0	38	0	0	1	1	0
	14	1	28	0	0	0	1	0
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	16	0	44	0	0	1	1	0

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	19	0	32	0	0	1	1	0
	20	1	25	0	0	1	1	0
Hospital40	1	0	34	0	0	0	0	0
	2	1	27	0	0	1	1	0
	3	0	43	0	0	1	1	0
	4	0	29	0	0	0	1	0
	5	0	23	0	0	1	1	0
	6	0	48	0	1	1	1	0
	7	0	34	0	0	1	1	0
Hospital41	1	0	34	0	0	0	1	1
	2	0	24	0	0	0	1	1
	3	0	33	0	0	0	1	1
	4	0	41	0	0	0	1	1
	5	0	29	0	0	0	1	1
	6	0	34	0	0	0	1	1
	7	0	17	0	0	0	1	1
	8	0	37	0	0	0	1	1
Hospital42	1	1	63	0	0	0	1	0
	2	1	63	0	0	0	1	1
	3	1	63	0	0	0	1	1
	4	0	54	0	0	0	1	0
	5	1		0	0	0	1	0
	6	0	41	0	0	0	1	0
	7	0		0	0	0	1	0
	8	0	43	0	0	1	1	0
Hospital43	1	0	33	0	0	1	1	0
	5	0	45	0	0	1	1	0
	6	0	43	0	0	1	1	0
Hospital44	1	1	19	0	0	0	1	0
Hospital45	1	1	42	0	0	0	1	0
	2	1	44	0	1	0	1	0
Hospital46	1	0	71	0	0	0	1	0
Hospital47	1	0	32	0	0	1	1	0
	2	1	45	0	0	1	1	0
	3	1	24	0	0	1	1	0
	4	0		0	0	1	1	0
	5	0	43	0	0	1	0	0
	6	0	30	0	0	1	1	0
	7	0	27	0	0	1	1	0
	8	0	40	0	0	1	1	0
	9	0	41	0	0	1	1	0
	10	1	48	0	0	1	1	0
	11	0	47	0	0	1	1	0
	12	0		0	0	0	0	0
Hospital48	1	1	26	1	0	1	1	0
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	3	0	25	0	0	1	1	0
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	5	0	46	0	0	1	1	0
	6	0	32	0	0	1	1	0

Hospital49	1	0	51	0	0	1	1	0
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	4	1	27	0	0	1	1	0
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	7	0	31	0	0	1	1	0
	9	0	37	0	0	1	1	0
	10	0	31	0	0	1	1	0
	11	1	21	0	0	1	1	0
	13	0	41	0	1	1	1	0
	14	0	33	0	1	1	1	0
	15	0	32	0	1	1	1	1
	16	0	32	0	1	1	1	0
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	18	0	41	0	1	1	1	0
	19	0	45	0	1	1	1	0
	20	0	33	0	1	1	1	0
Hospital50	1	1	11	1	0	0	1	1
Hospital51	1	1	26	1	0	0	1	0
	2	0	33	1	0	0	1	1
	3	0	21	1	0	0	1	1
Hospital52	1	1	29	0	0	1	1	1
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	3	0	23	1	0	0	1	1
	4	0	9	0	0	0	0	1
	5	0	34	0	0	0	1	1
	6	0	60	0	0	0	1	0

IgM	IgG	IgM or IgG	Symptomat	Fever	Cough	Sneeze	Sore Throat	Dyspnea
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Hospital	no. bed	no. staff	region	Healthcare	Patient par	Seroprev	Province	IgM+
1	30	193	Central	1	1	42.85714	ปทุมธานี	9
2	30	106	Northeast	1	1	0	อุดรธานี	0
3	34	130	East	1	0	5.555556	จันทบุรี	4
4	30	180	Northeast	0	1	66.66667	อุบลราชธานี	2
5	60	196	East	0	1	2.5	ชลบุรี	1
6	80	326	Central	0	1	0	นนทบุรี	0
7	90	300	East	1	1	5.128205	ชลบุรี	2
8	60	280	South	1	0	0	ตรัง	0
9	60	218	Central	1	1	0	นครปฐม	0
10	135	374	Northeast	1	1	0	นครราชสีมา	0
11	30	55	North	1	0	0	เชียงใหม่	0
12	30	200	Northeast	1	0	0	ขอนแก่น	0
13	60	278	Central	1	0	0	อุทัยธานี	0
14	50	160	Northeast	1	1	0	อุดรธานี	0
15	114	300	Northeast	1	1	0	อุดรธานี	0
16	60		South	1	0	0	สงขลา	0
17	30	131	Central	1	1	0	นครปฐม	0
18	30	120	Northeast	1	1	0	บุรีรัมย	0
19	10	100	South	0	1	0	ชุมพร	0
20	30	130	Central	1	0	0	ชัยนาท	0
21	154	520	Central	0	1	0	ลพบุรี	0
22	30	189	Central	0	1	20	สุโขทัย	1
23	120	450	Northeast	0	1	0	กาฬสินธุ์	0
24	60		Central	1	1	0	นนทบุรี	0
25	200	626	Central	1	1	5.263158	สมุทรปราการ	1
26	60	170	Northeast	1	0	0	ชัยภูมิ	0
27	30	120	Northeast	0	1	100	มุกดาหาร	1
28	75	250	West	1	0	0	ตาก	0
29	10	70	Central	1	0	12.5	พระนครศรีอยุธยา	1
30	90	300	Central	1	1	0	อุทัยธานี	0
31	30	188	East	1	1	0	จันทบุรี	0
32	30		Northeast	1	1	0	อุบลราชธานี	0
33	30	120	Central	1	0	30	พระนครศรีอยุธยา	6
34	30	72	Central	1	1	0	พิจิตร	0
35	30	140	Central	1	0	0	ชัยนาท	0
36	60	200	North	1	0	0	แพร่	0
37	30	84	Northeast	1	1	0	มหาสารคาม	0
38	30	7	South	1	0	0	ชุมพร	0
39	36	160	Northeast	1	1	16.66667	นครพนม	3
40	90	300	North	1	1	0	เชียงใหม่	0
41	100	500	Central	0	1	62.5	เพชรบุรี	5
42	30	100	Central	1	1	37.5	สุพรรณบุรี	3
43	60	230	South	1	0	66.66667	สุราษฎร์ธานี	2
44	30	92	South	0	1	0	นครศรีธรรมราช	0
45	30	200	Central	0	1	50	นนทบุรี	1
46	30	155	Central	0	1	100	ปทุมธานี	1
47	60	200	Northeast	1	1	16.66667	สุรินทร์	2
48	60	200	South	1	0	0	กระบี่	0
49	60	200	North	1	0	6.25	แม่ฮ่องสอน	1
50	120	428	Northeast	0	1	0	อุดรธานี	0
51	150	526	East	0	1	0	ชลบุรี	0

52	60	300	Central	1	1	16.66667	เพชรบุรี	1	

IgG+	IgMorIgG+	N
0	9	21
0	0	39
0	4	72
0	2	3
0	1	40
0	0	2
0	2	39
0	0	40
0	0	7
0	0	35
0	0	18
0	0	1
0	0	14
0	0	29
0	0	36
0	0	20
0	0	26
0	0	19
0	0	20
0	0	9
0	0	3
0	1	5
0	0	20
0	0	20
0	1	19
0	0	20
0	1	1
0	0	19
1	1	8
0	0	15
0	0	20
0	0	20
0	6	20
0	0	11
0	0	20
0	0	20
0	0	15
0	0	19
0	3	18
0	0	7
1	5	8
0	3	8
0	2	3
0	0	1
0	1	2
0	1	1
0	2	12
0	0	6
0	1	16
0	0	1
0	0	3

0 1 6

Hospital	no. bed	no. staff	region	Healthcare	Patient par	Seroprev	Province	IgM+
11	30	55	North	1	0	0	เชียงใหม่	0
36	60	200	North	1	0	0	แพร่	0
40	90	300	North	1	1	0	เชียงใหม่	0
49	60	200	North	1	0	6.25	แม่ฮ่องสอน	1
2	30	106	Northeast	1	1	0	อุดรธานี	0
4	30	180	Northeast	0	1	66.66667	อุบลราชธา	2
10	135	374	Northeast	1	1	0	นครราชสีม	0
12	30	200	Northeast	1	0	0	ขอนแก่น	0
14	50	160	Northeast	1	1	0	อุดรธานี	0
15	114	300	Northeast	1	1	0	อุดรธานี	0
18	30	120	Northeast	1	1	0	บุรีรัมย์	0
23	120	450	Northeast	0	1	0	กาฬสินธุ์	0
26	60	170	Northeast	1	0	0	ชัยภูมิ	0
27	30	120	Northeast	0	1	100	มุกดาหาร	1
32	30		Northeast	1	1	0	อุบลราชธา	0
37	30	84	Northeast	1	1	0	มหาสารคา	0
39	36	160	Northeast	1	1	16.66667	นครพนม	3
47	60	200	Northeast	1	1	16.66667	สุรินทร์	2
50	120	428	Northeast	0	1	0	อุดรธานี	0
1	30	193	Central	1	1	42.85714	ปทุมธานี	9
6	80	326	Central	0	1	0	นนทบุรี	0
9	60	218	Central	1	1	0	นครปฐม	0
13	60	278	Central	1	0	0	อุทัยธานี	0
17	30	131	Central	1	1	0	นครปฐม	0
20	30	130	Central	1	0	0	ชัยนาท	0
21	154	520	Central	0	1	0	ลพบุรี	0
22	30	189	Central	0	1	20	สุโขทัย	1
24	60		Central	1	1	0	นนทบุรี	0
25	200	626	Central	1	1	5.263158	สมุทรปรา	1
28	75	250	West	1	0	0	ตาก	0
29	10	70	Central	1	0	12.5	พระนครศรี	1
30	90	300	Central	1	1	0	อุทัยธานี	0
33	30	120	Central	1	0	30	พระนครศรี	6
34	30	72	Central	1	1	0	พิจิตร	0
35	30	140	Central	1	0	0	ชัยนาท	0
41	100	500	Central	0	1	62.5	เพชรบุรี	5
42	30	100	Central	1	1	37.5	สุพรรณบุรี	3
45	30	200	Central	0	1	50	นนทบุรี	1
46	30	155	Central	0	1	100	ปทุมธานี	1
52	60	300	Central	1	1	16.66667	เพชรบุรี	1
8	60	280	South	1	0	0	ตรัง	0
16	60		South	1	0	0	สงขลา	0
19	10	100	South	0	1	0	ชุมพร	0
38	30	7	South	1	0	0	ชุมพร	0
43	60	230	South	1	0	66.66667	สุราษฎรธา	2
44	30	92	South	0	1	0	นครศรีธรร	0
48	60	200	South	1	0	0	กระบี่	0
3	34	130	East	1	0	5.555556	จันทบุรี	4
5	60	196	East	0	1	2.5	ชลบุรี	1
7	90	300	East	1	1	5.128205	ชลบุรี	2
31	30	188	East	1	1	0	จันทบุรี	0

51	150	526	East		0	1	0	ชลบุรี	0

IgG+	IgMorIgG+	N
0	0	18
0	0	20
0	0	7
0	1	16
0	0	39
0	2	3
0	0	35
0	0	1
0	0	29
0	0	36
0	0	19
0	0	20
0	0	20
0	1	1
0	0	20
0	0	15
0	3	18
0	2	12
0	0	1
0	9	21
0	0	2
0	0	7
0	0	14
0	0	26
0	0	9
0	0	3
0	1	5
0	0	20
0	1	19
0	0	19
0	1	8
0	0	15
0	6	20
0	0	11
0	0	20
0	5	8
0	3	8
0	1	2
0	1	1
0	1	6
0	0	40
0	0	20
0	0	20
0	0	19
0	2	3
0	0	1
0	0	6
0	4	72
0	1	40
0	2	39
0	0	20

Region	Seroprev	IgMorIgG+	N	Sample
North	1.639344	1	61	3
Northeast	2.973978	8	269	11
Central	11.88525	29	244	13
South	1.834862	2	109	6
East	4.022989	7	174	2
Total	5.484247	47	857	35

0	0	3

All	%	Samplepop	Allpop	%
9	33.33333	2505118	6350499	39.44758
20	55	15064919	22014248	68.43259
26	50	10053397	18192361	55.26164
14	42.85714	5697112	9493757	60.00904
7	28.57143	2095999	4841806	43.28961
76	46.05263	35416545	60892671	58.16225

No	Hospital	No. bed	No. staff	region	Healthcare	Patient par	Seroprev	Province
1	1	30	193	Central	1	1	42.85714	ปทุมธานี
46	46	30	155	Central	0	1	100	ปทุมธานี
2	2	30	106	Northeast	1	1	0	อุดรธานี
14	14	50	160	Northeast	1	1	0	อุดรธานี
15	15	114	300	Northeast	1	1	0	อุดรธานี
50	50	120	428	Northeast	0	1	0	อุดรธานี
3	3	34	130	East	1	0	5.555556	จันทบุรี
31	31	30	188	East	1	1	0	จันทบุรี
4	4	30	180	Northeast	0	1	66.66667	อุบลราชธา
32	32	30		Northeast	1	1	0	อุบลราชธา
5	5	60	196	East	0	1	2.5	ชลบุรี
7	7	90	300	East	1	1	5.128205	ชลบุรี
51	51	150	526	East	0	1	0	ชลบุรี
6	6	80	326	Central	0	1	0	นนทบุรี
24	24	60		Central	1	1	0	นนทบุรี
45	45	30	200	Central	0	1	50	นนทบุรี
8	8	60	280	South	1	0	0	ตรัง
9	9	60	218	Central	1	1	0	นครปฐม
17	17	30	131	Central	1	1	0	นครปฐม
10	10	135	374	Northeast	1	1	0	นครราชสีม
11	11	30	55	North	1	0	0	เชียงใหม
40	40	90	300	North	1	1	0	เชียงใหม
12	12	30	200	Northeast	1	0	0	ขอนแก่น
13	13	60	278	Central	1	0	0	อุทัยธานี
30	30	90	300	Central	1	1	0	อุทัยธานี
16	16	60		South	1	0	0	สงขลา
18	18	30	120	Northeast	1	1	0	บุรีรัมย
19	19	10	100	South	0	1	0	ชุมพร
38	38	30	7	South	1	0	0	ชุมพร
20	20	30	130	Central	1	0	0	ชัยนาท
35	35	30	140	Central	1	0	0	ชัยนาท
21	21	154	520	Central	0	1	0	ลพบุรี
22	22	30	189	Central	0	1	20	สุโขทัย
23	23	120	450	Northeast	0	1	0	กาฬสินธุ
25	25	200	626	Central	1	1	5.263158	สมุทรปรา
26	26	60	170	Northeast	1	0	0	ชัยภูมิ
27	27	30	120	Northeast	0	1	100	มุกดาหาร
28	28	75	250	West	1	0	0	ตาก
29	29	10	70	Central	1	0	12.5	พระนครศรี
33	33	30	120	Central	1	0	30	พระนครศรี
34	34	30	72	Central	1	1	0	พิจิตร
36	36	60	200	North	1	0	0	แพร่
37	37	30	84	Northeast	1	1	0	มหาสารคา
39	39	36	160	Northeast	1	1	16.66667	นครพนม
41	41	100	500	Central	0	1	62.5	เพชรบุรี
52	52	60	300	Central	1	1	16.66667	เพชรบุรี
42	42	30	100	Central	1	1	37.5	สุพรรณบุรี
43	43	60	230	South	1	0	66.66667	สุราษฎรธา
44	44	30	92	South	0	1	0	นครศรีธรร
47	47	60	200	Northeast	1	1	16.66667	สุรินทร
48	48	60	200	South	1	0	0	กระบี่

49	49	60	200	North		1	0	6.25	แม่ฮ่องสอน

IgM+	IgG+	IgMorIgG+	N	Covidcase	pop	Covidprevalcne
9	0	9	21	39	1163604	0.003352
1	0	1	1	39	1163604	0.003352
0	0	0	39	10	1586646	0.00063
0	0	0	29	10	1586646	0.00063
0	0	0	36	10	1586646	0.00063
0	0	0	1	10	1586646	0.00063
4	0	4	72	3	537698	0.000558
0	0	0	20	3	537698	0.000558
2	0	2	3	15	1878146	0.000799
0	0	0	20	15	1878146	0.000799
1	0	1	40	134	1558301	0.008599
2	0	2	39	134	1558301	0.008599
0	0	0	3	134	1558301	0.008599
0	0	0	2	158	1265387	0.012486
0	0	0	20	158	1265387	0.012486
1	0	1	2	158	1265387	0.012486
0	0	0	40	7	643164	0.001088
0	0	0	7	22	920030	0.002391
0	0	0	26	22	920030	0.002391
0	0	0	35	19	2648927	0.000717
0	0	0	18	41	1779254	0.002304
0	0	0	7	41	1779254	0.002304
0	0	0	1	6	1802872	0.000333
0	0	0	14	1	328618	0.000304
0	0	0	15	1	328618	0.000304
0	0	0	20	134	1435968	0.009332
0	0	0	19	13	1595747	0.000815
0	0	0	20	21	511304	0.004107
0	0	0	19	21	511304	0.004107
0	0	0	9	0	326611	0
0	0	0	20	0	326611	0
0	0	0	3	2	755556	0.000265
1	0	1	5	3	595072	0.000504
0	0	0	20	3	983418	0.000305
1	0	1	19	143	1344875	0.010633
0	0	0	20	3	1137357	0.000264
1	0	1	1	4	353174	0.001133
0	0	0	19	3	665620	0.000451
1	0	1	8	4	820188	0.000488
6	0	6	20	4	820188	0.000488
0	0	0	11	0	536311	0
0	0	0	20	1	441726	0.000226
0	0	0	15	1	962665	0.000104
3	0	3	18	2	719136	0.000278
5	0	5	8	2	485191	0.000412
1	0	1	6	2	485191	0.000412
3	0	3	8	6	846334	0.000709
2	0	2	3	18	1068010	0.001685
0	0	0	1	12	1561927	0.000768
2	0	2	12	9	1396831	0.000644
0	0	0	6	20	476739	0.004195

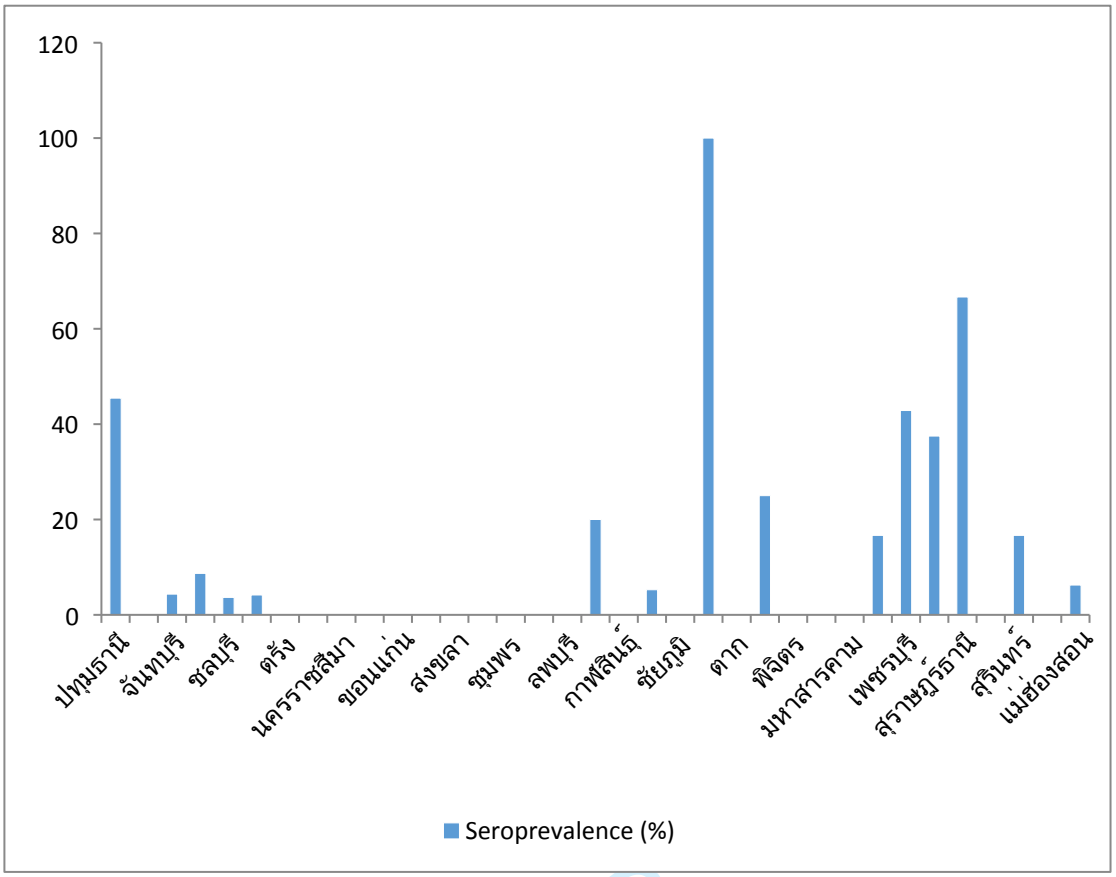
1	0	1	16	5	284138	0.00176

Province	Seroprevalen	N		Covidcase	Population	CovidPrev per 100000
ปทุมธานี	45.45455	10	22	39	1163604	3.351656
อุดรธานี	0	0	105	10	1586646	0.63026
จันทบุรี	4.347826	4	92	3	537698	0.557934
อุบลราชธา	8.695652	2	23	15	1878146	0.79866
ชลบุรี	3.658537	3	82	134	1558301	8.599109
นนทบุรี	4.166667	1	24	158	1265387	12.4863
ตรัง	0	0	40	7	643164	1.088369
นครปฐม	0	0	33	22	920030	2.391226
นครราชสีม	0	0	35	19	2648927	0.717272
เชียงใหม	0	0	25	41	1779254	2.304337
ขอนแกน	0	0	1	6	1802872	0.332802
อุทัยธานี	0	0	29	1	328618	0.304305
สงขลา	0	0	20	134	1435968	9.331684
บุรีรัมย	0	0	19	13	1595747	0.814665
ชุมพร	0	0	39	21	511304	4.107146
ชัยนาท	0	0	29	0	326611	0
ลพบุรี	0	0	3	2	755556	0.264706
สุโขทัย	20	1	5	3	595072	0.504141
กาฬสินธุ	0	0	20	3	983418	0.305058
สมุทรปรา	5.263158	1	19	143	1344875	10.63296
ชัยภูมิ	0	0	20	3	1137357	0.263769
มุกดาหาร	100	1	1	4	353174	1.132586
ตาก	0	0	19	3	665620	0.450708
พระนครศรี	25	7	28	4	820188	0.487693
พิจิตร	0	0	11	0	536311	0
แพร่	0	0	20	1	441726	0.226385
มหาสารคา	0	0	15	1	962665	0.103878
นครพนม	16.66667	3	18	2	719136	0.278112
เพชรบุรี	42.85714	6	14	2	485191	0.412209
สุพรรณบุรี	37.5	3	8	6	846334	0.70894
สุราษฎรธา	66.66667	2	3	18	1068010	1.685377
นครศรีธรร	0	0	1	12	1561927	0.768282
สุรินทร	16.66667	2	12	9	1396831	0.644316
กระบี่	0	0	6	20	476739	4.195168
แมฮองสอน	6.25	1	16	5	284138	1.759708

857

Spearman's Rho = 0.2225

p=0.1988



Province	Seroprevalen	N		Covidcase	Population	CovidPrev p	Region 1	North 2	Northe
เชียงใหม่	0	0	25	41	1779254	2.304337	1		
แพร่	0	0	20	1	441726	0.226385	1		
แม่ฮ่องสอน	6.25	1	16	5	284138	1.759708	1		
อุดรธานี	0	0	105	10	1586646	0.63026	2		
อุบลราชธา	8.695652	2	23	15	1878146	0.79866	2		
นครราชสีม	0	0	35	19	2648927	0.717272	2		
ขอนแก่น	0	0	1	6	1802872	0.332802	2		
บุรีรัมย์	0	0	19	13	1595747	0.814665	2		
กาฬสินธุ์	0	0	20	3	983418	0.305058	2		
ชัยภูมิ	0	0	20	3	1137357	0.263769	2		
มุกดาหาร	100	1	1	4	353174	1.132586	2		
มหาสารคา	0	0	15	1	962665	0.103878	2		
สุรินทร์	16.66667	2	12	9	1396831	0.644316	2		
นครพนม	16.66667	3	18	2	719136	0.278112	2		
ปทุมธานี	45.45455	10	22	39	1163604	3.351656	3		
นนทบุรี	4.166667	1	24	158	1265387	12.4863	3		
นครปฐม	0	0	33	22	920030	2.391226	3		
อุทัยธานี	0	0	29	1	328618	0.304305	3		
ชัยนาท	0	0	29	0	326611	0	3		
ลพบุรี	0	0	3	2	755556	0.264706	3		
สุโขทัย	20	1	5	3	595072	0.504141	3		
สมุทรปรากา	5.263158	1	19	143	1344875	10.63296	3		
ตาก	0	0	19	3	665620	0.450708	3		
พระนครศรี	25	7	28	4	820188	0.487693	3		
พิจิตร	0	0	11	0	536311	0	3		
เพชรบุรี	42.85714	6	14	2	485191	0.412209	3		
สุพรรณบุรี	37.5	3	8	6	846334	0.70894	3		
ตรัง	0	0	40	7	643164	1.088369	4		
สงขลา	0	0	20	134	1435968	9.331684	4		
ชุมพร	0	0	39	21	511304	4.107146	4		
สุราษฎรธา	66.66667	2	3	18	1068010	1.685377	4		
นครศรีธรรม	0	0	1	12	1561927	0.768282	4		
กระบี่	0	0	6	20	476739	4.195168	4		
จันทบุรี	4.347826	4	92	3	537698	0.557934	5		
ชลบุรี	3.658537	3	82	134	1558301	8.599109	5		
					35416545				
			857	864	Spearman's Rho = 0.2225				
					p=0.1988				

east 3Central 4South 5East

samplepop	
north	2505118
northeast	15064919
central	10053397
south	5697112
east	2095999
Thailand	35416545

	Thailand Population	WHO World Population
0-4	3,185,739	88,569
5-9	3,807,943	86,870
10-14	3,953,497	85,970
15-19	4,025,157	84,670
20-24	4,637,316	82,171
25-29	4,746,770	79,272
30-34	4,532,350	76,073
35-39	4,984,910	71,475
40-44	5,144,831	65,877
45-49	5,197,884	60,379
50-54	5,060,459	53,681
55-59	4,516,238	45,484
60-64	3,538,299	37,187
65-69	2,775,155	29,590
70-74	1,919,612	22,092
75-79	1,262,107	15,195
80-84	894,638	9,097
85-89	482,128	4,398
90-94	191,036	1,500
95-99	54,115	400
100 and more	18,969	50
Total	64,929,153	1,000,000

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	
Objectives	3	State specific objectives, including any prespecified hypotheses	4	
Methods				
Study design	4	Present key elements of study design early in the paper	4	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5	
Bias	9	Describe any efforts to address potential sources of bias	-	
Study size	10	Explain how the study size was arrived at	4-5	

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4-5
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6-7
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	6-7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11
		(*b*) Report category boundaries when continuous variables were categorized	-
		© If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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COVID-19 seroprevalence among hospital staffs and pre-procedural patients in Thai community hospitals: a cross-sectional study

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COVID-19 seroprevalence among hospital staffs and pre-procedural patients in Thai community hospitals: a cross-sectional study

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ABSTRACT

Objectives: We aimed to explore the seroprevalence of hospital staff comparing to preprocedural patients in Thai community hospitals to shed light on the situation of COVID-19 infection of frontline healthcare workers in low infection rate countries where mass screening was not readily available.

Design: Cross-sectional study.

Setting: 52 community hospitals in 35 provinces covered all regions of Thailand

Participants: 857 participants consisted of 675 hospital staff and 182 pre-procedural patients

Outcome measure: COVID-19 seroprevalence using a locally developed rapid IgM/IgG test kit

Results: Overall, 5.5% of the participants (47 of 857) had positive immunoglobulin M (IgM), 0.2% (2 of 857) had positive immunoglobulin G (IgG) which both of them also had positive IgM. Hospitals located in the central part of Thailand had the highest IgM seroprevalence (11.9%). Preprocedural patients had a higher rate of positive IgM than the hospital staff (12.1% vs. 3.7%). Participants with present upper respiratory tract symptoms had a higher rate of positive IgM than those without (9.6% vs. 4.5%). Three quarters (80.5%, 690 of 857) of the participants were asymptomatic, of which, 31 had positive IgM (4.5%) which consisted of 20 of 566 healthcare workers (3.5%) and 11 of 124 preprocedural patients (8.9%).

Conclusions: COVID-19 antibody test could detect a substantial number of potential silent spreaders in Thai community hospitals where the nasopharyngeal PCR was not readily available, and the antigen test was prohibited. Antibody testing should be encouraged for mass screening in a limited resource setting, especially in asymptomatic individuals.

Trial registration: Thai Clinical Trials Registry: TCTR20200426002

MeSH Keywords: COVID-19, severe acute respiratory syndrome coronavirus 2, Seroepidemiologic Studies, Hospitals, Thailand

Strengths and limitations of this study

► This study covered all regions in Thailand and consisted of community hospitals from 35 out of 77 provinces.

► We used a locally developed IgM/IgG test kit with high internal validation to shed light on the actual COVID-19 situation in areas in which nasopharyngeal PCR testing was not readily available.

► This study provided a real-life experience to gather crucial information despite restricted resources.

► We did not have a chance to perform the serological test among the COVID-19 confirmed cases as the mild case had to get quarantined and the moderate and severe ones were referred to a higher level of care, which could affect the seroprevalence.

► We could not perform multiple serological tests at different time points as doing so was not approved by the ethics committee.

INTRODUCTION

Polymerase chain reaction (PCR) was introduced as a diagnostic test of choice for coronavirus disease 2019 (COVID-19) infection. However, it might not be readily available or affordable in many facilities and could pose an unnecessary risk to the healthcare providers during the specimen collection. Besides, a recent study raised a concern of false-negative results from the nasopharyngeal PCR test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in patients with high pretest probability and encouraged the development of a highly sensitive test.[1]

Antibody testing provides additional information for epidemic investigation and control with high sensitivity and simplicity, especially when used along with the nasopharyngeal PCR test. At an early stage of the COVID-19 pandemic, antibody testing was utilized for mass screening to identify and track the missing silent spreaders in Singapore.[2] Asymptomatic patients are considered to be one of the important sources of COVID-19 transmission,[3] with approximately one-fifth transmission rate to close contact individuals.[4] Additionally, there was a 13% estimated proportion of asymptomatic COVID-19 patients in general and 37% in healthcare providers.[5]

While the nasopharyngeal PCR test was considered gold-standard, there were increasing studies that reported both PCR and antibody test results. In the early phase of pandemic, there was a study in China reported a 2.5% overall COVID-19 seroprevalence in the hospital setting with subgroup analysis of 1.8% in healthcare workers and 3.5% in asymptomatic patients.[6] Recent meta-analysis reported 8% SARS-CoV-2 seroprevalence in healthcare workers before vaccine initiation.[7]

An early study on the development of SARS-CoV-2 antibodies in symptomatic COVID-19 patients reported that immunoglobulin M (IgM) had the highest value during 20-22 days after onset while immunoglobulin G (IgG) had the highest value during 17-19 days after onset.[8] More complete information on immunoglobulin development was reported in a recent systematic review that IgM had median seroconversion time between four to 14 days, reached its peak at two to five weeks, then declined to an undetectable level at six weeks post-onset while IgG had median seroconversion time between 12-15 days, reached its peak at three to seven weeks, then diminished after eight weeks after onset.[9] Since SARS-CoV-2 infectivity was likely to diminish after eight to 13 days post-onset,[10] antibody tests for IgM seroprevalence might not suit for early diagnosis of current COVID-19 cases with infectivity, but would be more appropriate to support the diagnosis of recent COVID-19 infection after two weeks of onset.[11]

Preferably, utilization of both nasopharyngeal PCR and antibody tests would provide an accurate estimation of the COVID-19 situation in a specific area. However, there were several low- to middle-income countries that could not pay for the cost of nasopharyngeal PCR tests and had to restrict the eligibility for PCR testing to a limited population for the optimization of resource usage. In Thailand, the nasopharyngeal PCR test was offered in suspected individuals with strict criteria during the initial phase of the COVID-19 pandemic. As a more feasible, cheaper, and safer alternative to the nasopharyngeal PCR in a limited resource setting, the antibody test is not only useful for an epidemiological investigation but could also be used for mass screening of potential silent spreaders—asymptomatic COVID-19 individuals.[2]

Hospital is one of the best venues for getting and spreading pathogens. There are two types of people in the hospital who potentially are silent spreaders and need antibody testing: (1) healthcare workers who have a relatively higher risk of infection than laypersons, and (2) asymptomatic patients who need procedural treatment or operation but do not meet the criteria for nasopharyngeal PCR testing.

METHODS

Study Population

From 8th April to 26th June 2020, hospital staff and patients who needed procedural treatment or operation visiting the hospital during the recruiting period and did not meet the national nasopharyngeal PCR testing criteria in 244 hospitals (215 community hospitals and 29 general hospitals) from all regions of Thailand were recruited for antibody testing in their community hospital. Hospitals included in the study came from a national survey about willingness to use antibody testing for COVID-19 screening. Of 215 community hospitals, data from 52 hospitals (24.2%) in 35 provinces from all regions which could be considered representative of community hospitals across Thailand were readily available for the analysis performed on June 29, 2020. Participants with active symptoms meeting national criteria for nasopharyngeal PCR testing were quarantined and excluded. Participants were asked to answer a questionnaire about risk history for COVID-19, recent symptoms within the past two weeks, and previous nasopharyngeal PCR test results if available.

National criteria for nasopharyngeal PCR testing for COVID-19

National criteria for nasopharyngeal PCR testing for COVID-19 for symptomatic layperson during the study period included fever with one of the upper respiratory infection symptoms (cough, rhinitis, sore throat, anosmia, tachypnea, or dyspnea) and one of risk history (history of travel to a high-risk area, an occupation involving tourists, crowded place, or contact with many people, history of going to crowded place in the community, or history of close contact confirmed COVID-19 case) within 14 days before the onset of symptoms. For symptomatic healthcare workers, the criteria were less strict. Either fever or one of the upper respiratory infection symptoms was sufficient for PCR testing. During recruiting period, there was almost impossible for an asymptomatic person to get PCR tested.

Antibody testing

Baiya Rapid COVID-19 IgG/IgM test kit (Baiya Phytopharm, Thailand) which reports the presence of immunoglobulin M (IgM) and immunoglobulin G (IgG) qualitatively using lateral flow immunoassay technique and receptor-binding protein of spike protein of SARS-CoV-2 for antigen, was used in this study free of charge. The internal validation of the test kit using the serum of 51 nasopharyngeal PCR confirmed COVID-19 cases and 150 controls showed sensitivity 94.1% (48 of 51) and specificity 98.0% (147 of 150) for IgM or IgG antibody. Of 51 PCR confirmed COVID-19 cases, 56.9% (29 of 51) were IgM+ IgG-, 37.3% (19 of 51) were IgM+ IgG+, 5.9% (3 of 51) were IgM-IgG-. No IgM- IgG+ was detected in 51 PCR confirmed COVID-19 cases from interval validation. Participants with positive IgM were encouraged to have a nasopharyngeal PCR test if available. There was no hospital or center readily available for neutralizing antibody testing during the study period.

Age-adjusted seroprevalence

PCR confirmed COVID-19 cases were obtained from the Thailand government report on June 30, 2020. Seroprevalence data were presented as unadjusted seroprevalence and compared with direct age-adjusted seroprevalence using combined participating population, Thailand population, and world population provided by the world health organization (WHO) for 2000-2025 population.

Statistical analysis

Categorical data were presented with counts and percentages while continuous data were provided with median and

interquartile ranges. The 95% confidence interval (CI) of the seroprevalence was calculated by Wilson's method using binomial probabilities. Correlation between seroprevalence and PCR confirmed COVID-19 prevalence was tested using Spearman's correlation. Missing data were excluded. A two-tailed $p < 0.05$ was considered statistically significant. All data were analyzed using Stata 16.1 (College Station, TX).

Patient and public involvement statement

The research question and outcome measure were developed from both patient and public involvement. For patient involvement, visiting a hospital must not harm patients; however, the unknown status of COVID-19 infection in the pandemic period led to a doubtable situation of no harm. For public involvement, the national policy about COVID-19 test at the study period made unstable situation among the public, a national survey was conducted to identify the situation in the community and general hospitals to find places that should be the priority for this study to provide more confidence situation for hospital visiting and working. Patients and hospital staff who participated in this study had a report for their serology status, and the results of this study would be disseminated not only to participants but also to the public via an online channel to provide evidence of the actual situation.

RESULTS

Community hospital demographic

Overall, 52 community hospitals from 46.1% of provinces in Thailand (35 of 76) which consisted of 58.2% of national population (35,416,545 of 60,892,671) participated in this study. Participation rates varied across regions—Northeastern (55%), Central (50.0%), Southern (42.9%), Northern (33.3%), and Eastern (28.6%) (supplementary table E1).

Participant demographic

From 52 community hospitals, 857 participants which consisted of 675 hospital staff and 182 pre-procedural patients were included in the study. Their median age was 37 years (interquartile range 27–45), 74.7% were female, 98.8% were Thai, and 80.5% were asymptomatic. The most common symptoms were cough (9.7%), rhinitis (7.5%), sore throat (6.4%), fever (5.7%), and dyspnea (3.5%). History of travel to the high-risk area was 6.0%, history of close contact to the confirmed COVID-19 case was 15.4%, and 14.5% had nasopharyngeal PCR negative (table 1). Forty-seven participants (5.5%, 95% CI 4.1 to 7.2) had IgM antibodies against SARS-CoV-2 whereas the IgG antibody was found in two participants (0.2%, 95% CI 0.1 to 0.8). Participants from the Central region of Thailand

had the highest IgM seroprevalence (11.9%, 95% CI 8.4 to 16.5), while the Northern region had the lowest seroprevalence (1.6%, 95% CI 0.3 to 8.7) (figure 1).

Table 1 Demographic details of participants

	All Participants N (%)	Hospital Staff n (%)	Pre-procedural Patients n (%)
Total	857	675	182
Median age, years (25th–75th percentile)	37 (27–45)	36.5 (28–45)	37 (25–53)
Male	207 (24.1%)	145(21.5%)	62 (34.1%)
Female	640 (74.7%)	521 (77.2%)	119 (65.4%)
Unspecified	10 (1.2%)	9 (1.3%)	1 (0.5%)
Thai	847 (98.8%)	671 (99.4%)	176 (96.7%)
Non-Thai	10 (1.2%)	4 (0.6%)	6 (3.3%)
Region			
North	61 (7.1%)	59 (8.8%)	2(1.1%)
Northeast	269 (31.4%)	220 (32.6%)	49 (26.9%)
Central	244 (28.5%)	183 (27.1%)	61 (33.5%)
South	109 (12.7%)	88 (13.0%)	21 (11.6%)
East	174 (20.3%)	125 (18.5%)	49 (26.9%)
History of travel to high risk area			
Yes	51 (6.0%)	20 (3.0%)	31 (17.0%)
No	806 (94.0%)	655 (97.0%)	151 (83.0%)
History of close contact confirmed case			
Yes	132 (15.4%)	121 (17.9%)	11 (6.0%)
No	725 (84.6%)	554 (82.1%)	171 (94.0%)
Asymptomatic	690 (80.5%)	566 (83.9%)	124 (68.1%)
Symptomatic	167 (19.5%)	109 (16.1%)	58 (31.9%)
Fever	49 (5.7%)	17 (2.5%)	32 (17.6%)
Cough	83 (9.7%)	52 (7.7%)	31 (17.0%)
Rhinitis	64 (7.5%)	47 (7.0%)	17 (9.3%)
Sore throat	55 (6.4%)	37 (5.5%)	18 (9.9%)
Dyspnea	30 (3.5%)	3 (0.4%)	27 (14.8%)
Previous nasopharyngeal PCR status			
Negative	124 (14.5%)	77 (11.4%)	47 (25.8%)
Never tested	733 (85.5%)	598 (88.6%)	135 (74.2%)

Data were presented in counts and percentages unless otherwise specified.
PCR, polymerase chain reaction.

Age-adjusted immunoglobulin M (IgM) seroprevalence

Age-adjusted IgM seroprevalence with combined participating population showed almost similar results with unadjusted IgM seroprevalence. However, age-adjusted seroprevalence using Thailand population showed increasing seropositive rate in Thailand from 5.5% to 6.3%, Central region from 11.9% to 15.3%, and Northern region from 1.6% to 1.8%, while decreasing seroprevalence in Northeastern region from 3.0% to 1.6%, Eastern region from 4.0% to 2.8%, and Southern region from 1.8% to 1.5%. Adjusted with the world standard population from the World Health Organization (WHO 2000-2025) showed decreasing trends of seroprevalence both overall and in most regions (table 2).

Table 2 Unadjusted and age-adjusted immunoglobulin M seroprevalence in community hospitals across geographical regions of Thailand

Regions	Unadjusted IgM Seroprevalence	Age-adjusted IgM Seroprevalence with Combined Participating Population	Age-adjusted IgM Seroprevalence with Thailand Population	Age-adjusted IgM Seroprevalence with World Standard Population
Thailand*	5.5%	NA	6.3%	5.1%
Northern	1.6%	2.2%	1.8%	2.1%
Northeastern	3.0%	3.0%	1.6%	1.5%
Central*	11.9%	11.9%	15.3%	12.2%
Southern	1.8%	2.4%	1.5%	1.2%
Eastern	4.0%	3.9%	2.8%	2.6%

* Not include Bangkok which has no community hospital.
IgM, immunoglobulin M; NA, not available; WHO, World Health Organization.

Participant characteristics and seroprevalence

Pre-procedural patients had an unexpectedly higher proportion of positive IgM than the hospital staff (12.1% vs. 3.7%), especially patients in the Central region of Thailand (27.9%, 95% CI 18.2 to 40.2) while patients in the Northern and Southern regions showed zero seroprevalences. Also, hospital staff in the Central region had the highest seroprevalence (6.6%, 95% CI 3.8 to 11.1) while those in the Northern region had the lowest (1.7%, 95% CI 0.3 to 9.0). Overall, the seropositive prevalence was not different between males and females (5.8% vs. 5.5%). Paradoxically, the seroprevalences were higher in participants without a history of travel to a high-risk area (5.6% vs. 3.9%) and those without a history of close contact to confirmed COVID-19 case (5.7% vs. 4.5%) than their counterparts. The same paradox also applied to pre-procedural patients. Patients without travel history were likely to have an antibody for SARS-CoV-2 (13.9% vs. 3.2%) and patients without close contact to the case also had more chance to develop an antibody (12.3% vs. 9.1%). However, healthcare workers with travel history had slightly more chance to develop IgM (5.0% vs. 3.7%) and with close contact history (4.1% vs. 3.6%). In general, participants with upper respiratory tract symptoms had a higher chance of being seropositive (9.6% vs. 4.5%), of which dyspnea had the highest (30.0%, 95% CI 16.7 to 47.9). Likewise, pre-procedural patients with dyspnea had the most IgM positive (29.6%, 95% CI 15.9 to 48.5) and healthcare workers with dyspnea (33.3%, 95% CI 6.1 to 79.2). Of 690 participants without present upper respiratory tract symptoms, 31 had IgM positive for COVID-19 (4.5%, 95% CI 3.2 to 6.3) which consisted of 20 of 566 healthcare workers (3.5%, 95% CI 2.3 to 5.4) and 11 of 124 patients (8.9%, 95% CI

5.0 to 15.2). History of negative nasopharyngeal PCR was associated with a surprisingly higher chance of seropositive than those with no PCR test result (6.5% vs. 5.3%) (Table 3). Unfortunately, none of the participants with positive IgM had opportunities for nasopharyngeal PCR testing.

Table 3 Demographic characteristics and seroprevalence in hospital staff and pre-procedural patients

	All Participants		Hospital Staff		Pre-procedural Patients	
	N	IgM+	n	IgM+	n	IgM+
Total	857	47 (5.5%)	675	25 (3.7%)	182	22 (12.1%)
Median age, years (25th–75th percentile)	37 (27–45)		36.5 (28–45)		37 (25–53)	
Male	207 (24.1%)	12 (5.8%)	145(21.5%)	6 (4.1%)	62 (34.1%)	6 (9.7%)
Female	640 (74.7%)	35 (5.5%)	521(77.2%)	19 (3.6%)	119 (65.4%)	16 (13.4%)
Unspecified	10 (1.2%)	0 (0.0%)	9 (1.3%)	0 (0.0%)	1 (0.5%)	0 (0.0%)
Thai	847	47 (5.5%)	671	25 (3.7%)	176	22 (12.5%)
Non-Thai	10	0(0.0%)	4	0 (0.0%)	6	0 (0.0%)
Region						
North	61	1 (1.6%)	59	1 (1.7%)	2	0 (0.0%)
Northeast	269	8 (3.0%)	220	4(1.8%)	49	4 (8.2%)
Central	244	29 (11.9%)	183	12 (6.6%)	61	17 (27.9%)
South	109	2 (1.8%)	88	2 (2.3%)	21	0 (0.0%)
East	174	7 (4.0%)	125	6 (4.8%)	49	1 (2.0%)
History of travel to a high-risk area						
Yes	51	2 (3.9%)	20	1 (5.0%)	31	1 (3.2%)
No	806	45 (5.6%)	655	24 (3.7%)	151	21 (13.9%)
History of close contact confirmed case						
Yes	132	6(4.5%)	121	5(4.1%)	11	1 (9.1%)
No	725	41 (5.7%)	554	20 (3.6%)	171	21 (12.3%)
Asymptomatic	690	31 (4.5%)	566	20 (3.5%)	124	11 (8.9%)
Symptomatic	167	16 (9.6%)	109	5 (4.6%)	58	11 (19.0%)
Fever	49	7 (14.3%)	17	0 (0.0%)	32	7 (21.9%)
Cough	83	8 (9.6%)	52	1 (1.9%)	31	7 (22.6%)
Rhinitis	64	7 (10.9%)	47	2 (4.3%)	17	5 (29.4%)
Sore throat	55	8 (14.5%)	37	3 (8.1%)	18	5 (27.8%)
Dyspnea	30	9 (30.0%)	3	1 (33.3%)	27	8 (29.6%)
Previous nasopharyngeal PCR status						
Negative	124	8 (6.5%)	77	1 (1.3%)	47	7 (14.9%)
Never tested	733	39 (5.3%)	598	24 (4.0%)	135	15 (11.1%)

Data were presented in counts and percentages unless otherwise specified.
IgM+, immunoglobulin M positive; NA, not available; PCR, polymerase chain reaction.

COVID-19 prevalence and immunoglobulin M seroprevalence

PCR confirmed COVID-19 case and population data were acquired for participating provinces. Overall, COVID-19 prevalence was 2.44 cases per 100,000 population. Participating provinces in the Eastern region had the highest prevalence of COVID-19 (6.54 cases per 100,000 population) while provinces in the northeastern had the lowest prevalence (supplemental table E2). There was no correlation between IgM seroprevalence, and PCR confirmed COVID-19 prevalence (p=0.199).

Characteristics of immunoglobulin G seropositive participants

IgG was detected in two participants (0.2%, 95% CI 0.1 to 0.8) who also had a positive IgM antibody. In other words, we did not find any participants with isolated positive IgG. Participant A was a Thai female healthcare worker who worked in a community hospital in the Central region of Thailand. She had a sore throat but had no history of travel to a high-risk area or close contact to a confirmed COVID-19 case and did not have a nasopharyngeal PCR test before. Participant B was a Thai female preprocedural patient who visited another community hospital in the Central region. She had no symptoms, no history of travel to a high-risk area, or close contact to confirmed the COVID-19 case. Participant B had a previously negative nasopharyngeal PCR result (table 4).

Table 4 Characteristics of Participants who Developed Immunoglobulin G Antibody

	Age Range, years	Gender	Ethnicity	Region	Occupation	History of travel to a high-risk area	History of contact to a confirmed case	Symptoms	Previous PCR status
Participant A	56-60	Female	Thai	Central	HCW	No	No	Sore throat	Never tested
Participant B	41-45	Female	Thai	Central	Patient	No	No	No	Negative

HCW, healthcare worker; PCR, polymerase chain reaction; Age range was used for participant's privacy and confidentiality.

DISCUSSION

During an early phase of the pandemic in Thailand, which had approximately 61 million inhabitants located in the South-East Asia region, there were 5.5% overall estimated IgM and 0.2% overall IgG seroprevalence in community hospital staffs and pre-procedural patients. Overall IgM seroprevalence was highest in the community hospitals located in the central region of Thailand. Pre-procedural patients showed a higher estimated IgM seroprevalence than the healthcare workers (12.1% vs. 3.7%). Among asymptomatic participants accounted for approximately 80% of participants, the overall estimated IgM seroprevalence was 4.5% which could be subcategorized to 3.5% in healthcare workers and 8.9% in pre-procedural patients. Additionally, participants with present upper respiratory tract symptoms had a higher rate of positive IgM at 9.6%.

COVID-19 seroprevalence in asymptomatic staff and patients in Thai community hospitals was higher than in hospitals in China (4.5% vs. 2.5%).[6] Seroprevalence in asymptomatic hospital staff in Thailand was also higher than hospitals in China (3.5% vs. 1.8%),[6] but less than a tertiary hospital in Belgium (3.5% vs. 6.4%).[12] Moreover, seroprevalence in asymptomatic hospital staff in Thailand community hospital was higher than asymptomatic

hospital staffs in a Thai provincial hospital (3.5% vs 0.7%),[13] but was less than asymptomatic frontline firefighters/paramedics of US fire department (3.5% vs 7.7%).[14] Asymptomatic patients in Thailand seemed to have higher seroprevalence than in China (8.9% vs.3.5%).[6] Unlike China and Belgium where the seroprevalences were mostly from positive IgG, our study revealed mostly positive IgM. The possible explanation would be different study periods among studies that represented the different stages of epidemic in the regions. Comparison with a Belgium hospital should be interpreted with caution due to the unknown nasopharyngeal PCR status of Belgium subjects.

Most seropositive participants in this study had positive IgM only while only a few had both positive IgM and IgG. We conjecture three possible explanations which might relate to the dominance of IgM positive results. First, the relation of antibody testing timepoint and the onset of COVID-19 might play a significant contribution.[15] Although both IgM and IgG could develop to be detectable in some patients during the first-week post-onset,[16] approximately 70% of symptomatic patients developed IgM to detectable level during the second week after onset and raised to 90% of total antibody test positive by days 11-24 post-onset.[17] Regards the immunoglobulin level, COVID-19 confirmed cases usually had higher IgM levels than IgG during the first two weeks after onset with a reversal afterward.[18] The study period was an early stage of the pandemic in Thailand, thus the participants with recent COVID-19 infection might not develop detectable IgG yet, thus lead to a false-negative result of the IgG test.[19] Second, there was heterogeneity regards antibody development since some COVID-19 patients might have impregnable innate immunity and recovered from the disease without developing any antibody.[20] Third, the exclusion criteria of our observational study excluded all confirmed COVID-19 cases who had a higher chance of developed IgG.

Since the study was based on a hospital setting, the IgM seroprevalence in the study might be an overestimation of the general population due to the higher risk of COVID-19 infection in hospitals,[21] especially in the Central region of Thailand where the high population density might associate with the increasing transmission.[22] [23] On the other hand, the antibody test for IgM might underestimate the true prevalence of COVID-19 infection in the hospital setting, particularly those who were in the infectious stage since the IgM seroprevalence was more effective to support the diagnosis of recent COVID-19 infection after two weeks of onset,[11] while the infectivity was likely to plummet during the first and second week of onset.[10]

There was a very high proportion of participants who had been contacted with COVID-19 confirmed cases. This situation was not unexpected because the participants who had contact with the confirmed case might seek medical care and nasopharyngeal PCR test, but they were not eligible for the PCR test due to national policy during the study period required patients to be both symptomatic and had a high risk of exposure to COVID-19 to get tested. However, people with a history of close contact to confirmed COVID-19 cases or travel to a high-risk area turned out to have a low COVID-19 seroprevalence in our study. One possible explanation could be the successful implementation of the national nasopharyngeal PCR-based screening policy, low barrier to medical care under the Universal Coverage scheme as well as disease awareness and health literacy of the Thais. People with those predefined risks might have already sought medical attention; several cases might have been identified with the PCR test and were either quarantined or sent to proper care. The remaining eligible individuals might be dominated by those without the predefined risks.

To prevent nosocomial spread in a community hospital or primary hospital setting, hospital staff should be tested for COVID-19 before working their routine and should repeat the test at a specified period. Antibody testing was less uncomfortable than nasopharyngeal PCR testing which might lead to more compliance when hospital staff was planned to get multiple tests. False-negative could occur in any test. High sensitivity testing was encouraged for high-risk populations including hospital staff to reduce false negatives.[1] Negative result on nasopharyngeal PCR with negative antibody test or IgG positive only might be acceptable for hospital staff starting the work when such highly sensitive test was not completely developed. To help prevent community spread in an aspect of a community hospital setting, patients who visited the hospital with any chief complain should be tested with rapid antibody testing to screen some potential spreader and prevent them from returning to the community during spreadable period especially when nasopharyngeal PCR testing was not readily available in a remote area.

Serological testing provides some crucial epidemiological information and would have been more effective when combined with other diagnostic tests such as nasopharyngeal PCR or rapid antigenic tests. However, there was a unique situation in Thailand during the study period in which the eligibility criteria for nasopharyngeal swabs for PCR test were very strict and those who should have been tested mostly did not meet the strict criteria. Moreover, the rapid antigenic tests were not approved in Thailand until July 2021. While all participants with positive results from the free-of-charge rapid IgM/IgG test provided in this study were encouraged to get nasopharyngeal PCR

testing, a majority of community hospitals still did not have access to the PCR testing because of both financial and non-financial reasons. The recommendation for nasopharyngeal PCR testing after positive rapid IgM/IgG test was not fully complied so we did not have information about the participants with positive IgM. However, with the immunoglobulin status and PCR results, we can shape the situation more accurately for both individual and regional views. Hopefully, with this and other vigorous and dedicated studies on antibody status around the globe, serology testing would provide useful information for pandemic control.

Given the fact that IgM represents a recent infection while IgG is suggestive of past infection, excluding COVID-19 confirmed cases who had a higher chance of developing IgG during the study period would underestimate the actual IgG seroprevalence and underestimate the actual proportion of seropositive participants who had previous nasopharyngeal PCR testing. While this might be considered a limitation of our study as compared to other studies that did not exclude COVID-19 confirmed cases, our observation reflected a real picture of seroprevalence in a country with low COVID-19 incidence and mortality. We did not have a chance to perform the serological test among the COVID-19 confirmed cases as the mild case had to get quarantined and the moderate and severe ones were referred to a higher level of care. Also, we could not perform multiple serological tests at different time points as doing so was not approved by the ethics committee.

Only 2 out of 47 IgM-positive participants also had IgG-positive and none of the IgM-positive participants got subsequent nasopharyngeal PCR test after IgM-positive status. There was a possibility that IgM positive might be false positive. However, the false-positive rate for IgM or IgG was 2% according to internal validation of the test kit while IgM positive seroprevalence was 5.5%. While the false positive of IgM might occur due to imperfection of test kit and no confirmation with PCR test after positive antibody against COVID-19 which might lead to overestimation of actual IgM seroprevalence, this limitation shaped the real-world situation in an early phase of pandemic awareness in a community hospital setting where more advanced test methods were not readily available.

CONCLUSIONS

COVID-19 antibody test could detect a substantial number of potential silent spreaders in Thai community hospitals where the nasopharyngeal PCR was not readily available, and the antigen test was prohibited. Antibody testing should be encouraged for mass screening in a limited resource setting, especially in asymptomatic individuals.

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Contributors TN conceptualized the study, design the methodology, administrated the project, contributed to data curation and clinical investigation, validate the data, performed formal analysis and provided software, visualized the data, and wrote the original draft of the manuscript. KP conceptualized the study, design the methodology, administrated the project, contributed to data curation and clinical investigation, validate the data, performed formal analysis and provided software, provided resources for the study, supervised the study, and wrote the original draft of the manuscript. KC contributed to data curation and clinical investigation, and validate the data. NH conceptualized the study, design the methodology, administrated the project, provided resources for the study, and supervised the study. All authors reviewed, edited the final manuscript, agreed to be held accountable for all aspects of the work related to its accuracy and integrity.

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Competing Interests None declared.

Patient and public involvement Patient 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 required.

Ethics approval Ethics approval was obtained from the Institutional Review Board of Chulalongkorn University (IRB No.236/63), Ethics Committee of National Cancer Institute Thailand (EC No.015/2563), Research Ethics Committee of Nan Hospital (REC No.063/2563), Ethics Committee of Chaophraya Yommarat Hospital (YM No.013/2563), Institutional Review Board of Songkhla Hospital (IRB No.2020-Md-J3-04001), Ethics Committee of Lampang Hospital (EC No.26/63), Ethics Committee of Sikhio Hospital (SK No.2020/001), Ethics Committee of Samut Sakhon Hospital, Research Ethics Committee of Prapokklao Hospital (CTIREC No.030/63), Institutional Review Board of Burapha University (HS No.027/2563), Ethics Committee of Srinakharinwirot University (SWUEC No. 119/2563F), Institutional Review Board of Phaholpolpayuhasena Hospital (IRB No.2020-04), Institutional Review Board of Samitivej Sukhumvit Hospital (IRB No.001/2563), Research Ethics Committee of Pattani Provincial Public Health Office (RECPTN No.015/63), Institutional Review Board of Bangplee Hospital (IRB No.1/2563), Institutional Review Board of Chonburi Hospital (IRB No.08/2563), Institutional Review Board

of Surin Hospital (IRB No.15/2563), Institutional Review Board of Child and Adolescent Mental Health Rajanagarindra Institute (IRB No.2563/005) and Institutional Review Board of Sukhothai Hospital (IRB No.44/2563). Given no ethics committees are available in the participating community hospitals, participation in this study was approved by the hospital directors or representatives. All participants provided written informed consent including consent for publication of raw data. (Thai Clinical Trials Registry: TCTR20200426002)

Data availability statement All data relevant to the study are included in the article; the anonymized dataset is available upon request by emailing doctorkrit@gmail.com

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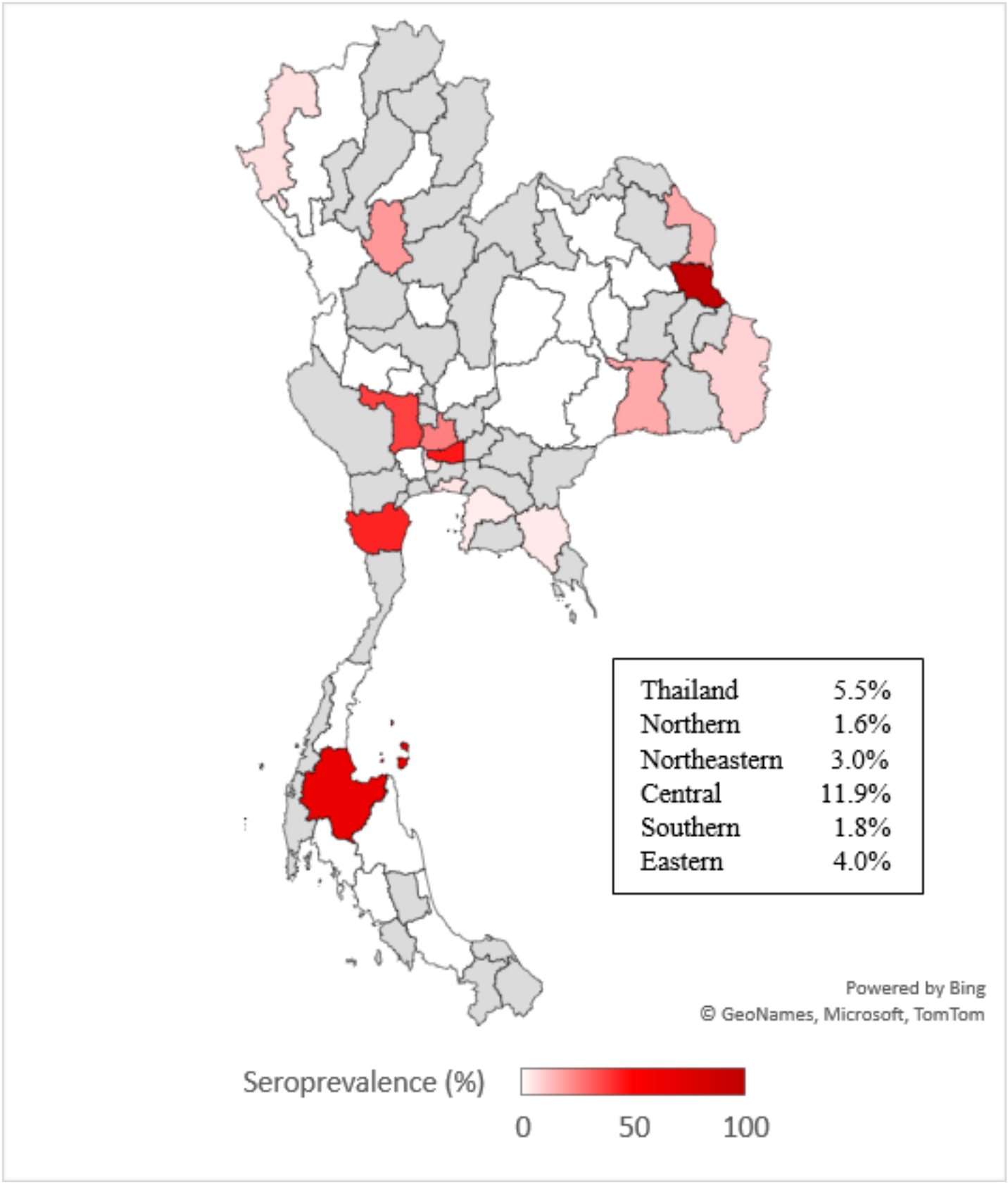
Figure legend

Figure 1 Unadjusted IgM seroprevalence of hospital staffs and pre-procedural patients in community hospitals across geographical regions of Thailand. Seroprevalence was scaled into color gradient which white region represented the lowest seroprevalence and dark red region represented the highest seroprevalence. Gray region represented region that was not participated in the study.


Thailand 5.5%
Northern 1.6%
Northeastern 3.0%
Central 11.9%
Southern 1.8%
Eastern 4.0%
Powered by Bing
© GeoNames, Microsoft, TomTom
Seroprevalence (%)
0
50
100

COVID-19 Antibody in Thai Community Hospitals

SUPPLEMENTARY FILES

Supplemental Table E1 Geographical distribution of 52 participating community hospitals

	Participating Provinces	Total Provinces	Population of Participating Provinces	Population of All Provinces
Thailand*	35 (46.1%)	76	35,416,545 (58.2%)	60,892,671
Northern	3 (33.3%)	9	2,505,118 (39.4%)	6,350,499
Northeastern	11 (55.0%)	20	15,064,919 (68.4%)	22,014,248
Central*	13 (50.0%)	26	10,053,397 (55.3%)	18,192,361
Southern	6 (42.9%)	14	5,697,112 (60.0%)	9,493,757
Eastern	2 (28.6%)	7	2,095,999 (43.3%)	4,841,806

* Not include Bangkok which has no community hospital.
Data were presented in counts and percentages.

Supplemental Table E2 Number and prevalence of PCR confirmed COVID-19 cases in participating provinces

	PCR Confirmed COVID-19 Cases	Population	PCR Confirmed COVID-19 Prevalence per 100,000 Population
Overall	864	35,416,545	2.44
Northern	47	2,505,118	1.88
Chiang Mai	41	1,779,254	2.30
Mae Hong Son	5	284,138	1.76
Phrae	1	441,726	0.23
Northeastern	85	15,064,919	0.56
Buriram	13	1,595,747	0.81
Chaiyaphum	3	1,137,357	0.26
Kalasin	3	983,418	0.31
Khon Kaen	6	1,802,872	0.33
Maha Sarakham	1	962,665	0.10
Mukdahan	4	353,174	1.13
Nakhon Phanom	2	719,136	0.28
Nakhon	19	2,648,927	0.72
Ratchasima			
Surin	9	1,396,831	0.64
Ubon Ratchathani	15	1,878,146	0.80
Udon Thani	10	1,586,646	0.63
Central	383	10,053,397	3.81
Ayutthaya	4	820,188	0.49
Chainat	0	326,611	0.00
Lopburi	2	755,556	0.26
Nakhon Pathom	22	920,030	2.39
Nonthaburi	158	1,265,387	12.49
Pathum Thani	39	1,163,604	3.35
Phetchaburi	2	485,191	0.41
Phichit	0	536,311	0.00
Samut Prakan	143	1,344,875	10.63
Sukhothai	3	595,072	0.50
Suphanburi	6	846,334	0.71
Tak	3	665,620	0.45
Uthaithani	1	328,618	0.30
Southern	212	5,697,112	3.72
Chumphon	21	511,304	4.11
Krabi	20	476,739	4.20
Nakhon Si	12	1,561,927	0.77
Thammarat			
Songkhla	134	1,435,968	9.33
Surat Thani	18	1,068,010	1.69
Trang	7	643,164	1.09
Eastern	137	2,095,999	6.54
Chanthaburi	3	537,698	0.56
Chonburi	134	1,558,301	8.60

PCR, polymerase chain reaction.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	
Objectives	3	State specific objectives, including any prespecified hypotheses	4	
Methods				
Study design	4	Present key elements of study design early in the paper	4	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5	
Bias	9	Describe any efforts to address potential sources of bias	-	
Study size	10	Explain how the study size was arrived at	4-5	

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	4-5
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6-7
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	6-7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11
		(*b*) Report category boundaries when continuous variables were categorized	-
		© If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.