Original Article

Knowledge, attitude and practice of health care professionals on laboratory diagnosis of COVID-19

Tapasyapreeti Mukhopadhyay[1], Jay Relan[2], Arulselvi Subramanian[1], Amit Lathwal[3]

[1]Department of Laboratory Medicine, Jai Prakash Narayan Apex Trauma Centre, [2]Department of Cardiology, [3]Department of Hospital Administration, All India Institute of Medical Sciences, New Delhi, India

Abstract

Background: Coronavirus disease-2019 (COVID-19) is currently a global public health concern. Thorough knowledge of diagnostics of COVID-19 amongst health care professionals (HCPs) is critical for timely and accurate diagnosis. The aim of the study was to assess the knowledge, attitude, and practice among HCPs related to the laboratory diagnosis of COVID-19. **Materials and Methods:** In this cross-sectional study, participants completed a self-administered questionnaire on KAPs regarding COVID-19 laboratory diagnosis. Knowledge and practice scores were calculated and categorized based on the number of correct responses. Predictors of knowledge and practice scores were identified by logistic regression analyses. **Results:** In all, 347 HCPs participated. Most participants had an average knowledge score and suboptimal practice score. Independent predictors of getting an average knowledge score were being indirectly involved in laboratory diagnosis of COVID-19 (odds ratio, OR: 2.591; 95% confidence interval, CI: 1.106–6.070), and having a government website as a major source of information (OR: 6.184; 95% CI: 1.185–32.286). Of all, 66.3% thought that testing rate for COVID-19 detection in India is unsatisfactory and 67.2% feared getting infected at work due to delays in test results. Most participants (90.5%) felt that more training programs related to laboratory diagnosis are needed. Practice scores significantly differed among HCPs of opposite sexes, different professions, and different information sources. **Conclusions:** Our results highlight the need for planning constructive strategies to improve KAP among HCPs related to the laboratory diagnosis of COVID-19. Timely dissemination of correct information to HCPs by the health authorities is critical to win this battle against COVID-19.

Keywords: Coronavirus, healthcare worker, laboratory medicine, pandemic, public health, SARS-CoV-2

Introduction

The pandemic of coronavirus disease 2019 (COVID-19), is a major global public health concern. The number of laboratory-confirmed cases and mortality due to COVID-19 continue to increase in many parts of the world and some are even experiencing and preparing to combat the second wave of the pandemic.[1] The knowledge on the diagnostics of COVID-19 amongst health care professionals (HCPs) is critical to allow timely and accurate diagnosis and also ensure safety of themselves and the patients. Putting the diagnostics in place is a major step to counter the spread and aid in the management of any infectious disease. Organizations responsible for international public health like the World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) have been continuously updating guidelines for the same.[2,3] The information is especially useful for the family doctors who are often the first contacts of patients and have a huge role in differentiating patients with respiratory

Address for correspondence: Dr. Arulselvi Subramanian, Department of Laboratory Medicine, Jai Prakash Narayan Apex Trauma Centre, All India Institute Medical Sciences, New Delhi - 110 029, India.
E-mail: arulselvi.jpnatc@gmail.com

Received: 14-12-2020 **Revised:** 21-02-2021
Accepted: 09-04-2021 **Published:** 31-05-2021

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_2459_20

How to cite this article: Mukhopadhyay T, Relan J, Subramanian A, Lathwal A. Knowledge, attitude and practice of health care professionals on laboratory diagnosis of COVID-19. J Family Med Prim Care 2021;10:1922-30.

symptoms from those with COVID-19, and treating patients without delay.[4]

However, increased circulation of misinformation on various social media platforms is bound to cause confusion and affect knowledge, attitude, and practices (KAP) of HCPs regarding the current testing indications and guidelines for sample collection and transport. The paucity of published literature on the assessment of knowledge about sample collection, transport, and processing for COVID-19 amongst HCPs prompted us to conduct the study. The aim of the study was to assess the KAP of HCPs related to laboratory diagnosis of COVID-19 through a structured, self-administered questionnaire using an online platform. By highlighting the knowledge gap, this study could provide baseline data to the government, individual institutional administrators, to plan and release focused strategies to decrease pre-analytical errors, false negative results, and unnecessary delays in results.

Materials and Methods

Study design and setting

This was a cross-sectional survey conducted in May 2020. All HCPs working in India were eligible to participate in the study. HCPs were defined as all people engaged in activities intended primarily to improve health.[5] Our study included doctors, nursing officers, medical technologists, scientists, medical students and trainees. HCPs were recruited by convenience sampling and the call for participation was made on social media (WhatsApp; Facebook, Inc., CA, USA) within the 2-week data collection period. The message/social media post included general description about the survey in English, along with the web link to access it. Participation was strictly voluntary and no incentives were given. Complete confidentiality was assured. Only those who gave consent to participate in the survey were directed to the questionnaire.

Study instrument, validation and data collection

Data were collected online, using the platform Google Forms (via docs.google.com/forms) through a self-administered, pre-tested, and structured questionnaire in English. The questionnaire was developed using information from recently published literature on COVID-19.[2,3,6-12] The questionnaire was pre-tested in a pilot study before distributing to the study sample. The pilot study included 10 experienced HCPs with a clinical or research background. Pilot study results helped to ensure the practicability of questionnaire and validity of questions and responses, by allowing questionnaire refinement through rewording and reframing of statements. The data collected in the pilot study were excluded from the final results.

The questionnaire was composed of 48 questions divided in five sections. The first section comprised 11 questions related to the demographics and general information about the participants. The participants were questioned about their age, sex, place of work, duration of work experience, presence of any facility for COVID-19 testing in their workplace, their type of involvement in the laboratory diagnosis of COVID-19, and their major source of information about the same. The place of work was dichotomized as Tier 1 city and others. Eight cities were considered as Tier 1 cities as defined by the Government of India based on house rent allowance.[13] Type of involvement in the laboratory diagnosis of COVID-19 was categorized into three groups: (i) 'Direct' – HCPs involved in sample collection and transport and/or working in the COVID-19 testing laboratory, (ii) 'Indirect' – HCPs managing confirmed or suspected COVID-19 patients admitted in the hospital or working in clinical laboratories other than for COVID-19 detection, and (iii) 'Not at all' – HCPs who did not fit in both (i) and (ii). The second section assessed knowledge of participants on the laboratory diagnosis of COVID-19. It consisted of 15 constructed statements with the response options 'yes', 'no', and 'I don't know'. The first three statements (K1–3) tested the knowledge about the guidelines on indications and timing for testing. The next seven statements (K4–10) were about collection and transport of samples. Following three statements (K11–13) were based on the testing methodology and reporting of the results while the last two statements (K14–15) were about biosafety. A scoring system was applied to assess the level of knowledge with 1 point for each correct response and none for incorrect or 'I don't know' response. The cumulative score (knowledge score) ranged from 0 to 15, with a higher score indicating better knowledge. For analysis, participants were grouped into three categories on the basis of their knowledge score: low (score <5), average (score 5–10), and high score (score >10). Both average and high knowledge scores were considered as acceptable scores while low knowledge score was considered unacceptable. The third section had 14 statements to assess the attitude of HCPs towards laboratory diagnosis of COVID-19. A five-point Likert scale was used to ascertain the level of agreement or disagreement for the statements (from 1 to 5, 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree). The fourth section had six questions to assess the practice/behavior adopted to acquire information about the laboratory diagnosis of COVID-19. Statements related to core practices performed by HCPs directly involved in laboratory diagnosis were not included in the questionnaire, keeping in mind the heterogeneity of the study population. Rather, the practice statements focused on potential aspects that could influence the testing process. A scoring system similar to that used for knowledge assessment was applied to assess the behavior. A cumulative score (practice score) of >3 was considered good. In the last section, participants were given an option to give feedback regarding the length of questionnaire and also had provision for comments.

Sample size calculation and statistical analysis

The sample size was determined using a margin of error of 5%, a confidence interval (CI) of 95%, and an expected rate of acceptable knowledge (average or high knowledge score) in the study population to be 70%, based on the pilot study. The minimum sample size estimated for the study was 323. A sample size of 347 HCPs was enrolled to counter methodological errors.

Data were exported to IBM SPSS v23 software (IBM, Armonk, NY, USA) for analyses. The demographic and other characteristics of the study participants were summarized using means and standard deviation for quantitative variables and proportions for qualitative variables. Knowledge and practice scores were presented as means with standard deviation and further categorized as: knowledge score (low = 0–4, average = 5–10, and high score = 11–15); practice score (suboptimal = 0–3, good = 4–6). Differences in knowledge and practice scores in relation to demographic and occupational characteristics were assessed using independent samples t-tests and one-way analysis of variance (ANOVA), as applicable. The response to the attitude section was described as percentages. Logistic regression models were used to calculate crude and adjusted odds ratios (OR) as well as corresponding 95% CIs of independent variables to identify predictors of knowledge and practice scores. Linear regression model was constructed to predict practice score based on knowledge score. The level of significance was set at $P < 0.05$.

Results

Study population and sociodemographic characteristics

A total of 347 HCPs participated in the study [Table 1]. Most of the participants were doctors (77.7%) and a majority (74.9%) were working in institutions with diagnostic facilities for detection of COVID-19. Only a few (5.5%) were working in the COVID-19 diagnostic laboratory. Of all the doctors, 46.8% doctors did not

Table 1: Demographic characteristics, mean knowledge, and mean practice scores of participants* (*n*=347)

Characteristics	*n* (%)	Knowledge score (SD)	*t*/*F*	*P*	Practice score (SD)	*t*/*F*	*P*
City of work							
Tier 1 city	261 (75.2)	7.96 (2.22)	1.081	0.281	2.75 (1.61)	2.012	0.045
Others	84 (24.8)	7.65 (2.40)			2.35 (1.65)		
Gender							
Female	144 (41.5)	7.94 (2.23)	0.501	0.617	2.39 (1.64)	-2.520	0.012
Male	203 (58.5)	7.81 (2.32)			2.83 (1.60)		
Age (in years)							
<30	102 (29.4)	7.57 (2.15)	1.307	0.272	2.64 (1.68)	0.519	0.596
30-50	219 (63.1)	8.01 (2.36)			2.69 (1.62)		
>50	26 (7.5)	7.81 (2.14)			2.35 (1.52)		
Profession							
Doctor	270 (77.7)	8.01 (2.25)	3.307	0.004	2.70 (1.57)	3.487	0.002
Medical technologist	38 (11.0)	8.08 (2.33)			3.11 (1.81)		
Nursing officer	11 (3.2)	7.55 (1.57)			2.00 (1.26)		
Student/trainee	25 (7.2)	6.36 (2.30)			1.82 (1.70)		
Scientist	3 (0.9)	6.33 (2.08)			1.00 (1.00)		
Duration of work experience (years)							
<1	31 (8.9)	6.84 (2.24)			2.00 (1.93)	2.113	0.098
1-5	85 (24.5)	8.01 (2.23)	2.347	0.073	2.84 (1.50)		
5-10	101 (29.1)	7.98 (2.16)			2.72 (1.63)		
>10	130 (37.5)	7.92 (2.38)			2.62 (1.60)		
Diagnostic facility in hospital							
Yes	260 (74.9)	7.93 (2.24)			2.74 (1.67)	1.864	0.063
No	87 (25.1)	7.68 (2.41)	0.880	0.380	2.37 (1.48)		
Involvement in laboratory diagnosis of COVID-19							
Directly	52 (15.0)	8.60 (2.07)	11.041	0.000	3.96 (1.60)	38.390	0.000
Indirectly	132 (38.2)	8.30 (2.18)			2.91 (1.54)		
Not involved	162 (46.8)	7.28 (2.30)			2.00 (1.38)		
Working in COVID-19 diagnostic laboratory							
Yes	19 (5.5)	8.58 (1.87)	1.405	0.161	4.68 (1.38)	5.871	0.000
No	328 (94.5)	7.82 (2.30)			2.53 (1.56)		
Major information source							
CDC or WHO website	80 (23.1)	8.05 (2.39)	1.855	0.102	3.01 (1.63)	6.744	0.000
Government website	71 (20.5)	8.20 (1.79)			2.99 (1.60)		
Scientific articles	79 (22.8)	8.06 (2.14)			2.72 (1.40)		
Workshop or training	25 (7.2)	7.88 (2.40)			3.16 (1.79)		
Social media	76 (22.0)	7.26 (2.57)			1.84 (1.54)		
Newspaper	15 (4.4)	7.20 (2.54)			1.93 (1.62)		

*Numbers do not always add up to 347 because of missing responses; continuous data are presented as mean (standard deviation (SD)); categorical data are presented as count (%); COVID-19, coronavirus disease-2019; CDC, Centers for Disease Control and Prevention have any involvement in the laboratory diagnosis of COVID-19. Most (74.1%) of the participants found the length of the questionnaire to be appropriate, however, some (22.5%) found it lengthy and others (3.5%) found it short.

Assessment of knowledge

The mean knowledge score was 7.8 ± 2.2. Overall, 85.3% of all the participants had an acceptable knowledge score (11.8% - high score, 73.5% - average score). The statements to assess knowledge, their correct responses, and the percentage of participants who responded correctly are shown in Table 2. The knowledge score was significantly different among the various professions ($P = 0.004$), with medical technologists having the highest mean knowledge score (8.08 ± 2.33), followed by doctors (8.01 ± 2.25), nursing officers (7.55 ± 1.57), medical students or trainees (6.36 ± 2.30) and lastly scientists (6.33 ± 2.08). The knowledge score was also significantly affected by the involvement of HCPs in laboratory diagnosis of COVID-19, with those directly involved having the highest mean knowledge score of 8.60 ± 2.07 ($P < 0.001$) [Table 1]. The knowledge scores were not significantly different across genders, age groups, duration of experience, presence or absence of diagnostic facility at the workplace and major information source.

Table 2: Participants' knowledge on laboratory diagnosis of COVID-19

S. No	Questions	Responses*
K1	Testing is indicated in all asymptomatic healthcare workers	Yes-93 **No-236 (68.0%)** I don't know-18
K2	Antibody detection-based tests are approved for screening	Yes-196 **No-117 (33.7%)** I don't know-34
K3	The first specimen to be collected within 3 days of symptom onset and no later than 7 days	**Yes-221 (63.6%)** No-82 I don't know-44
K4	The person collecting the sample for testing and receiving the sample in the laboratory must be wearing PPE	**Yes-340 (97.9%)** No-4 I don't know-3
K5	The nasopharyngeal swab is the preferred specimen over the oropharyngeal swab	**Yes-265 (76.4%)** No-52 I don't know-30
K6	A cotton swab should be used for taking the sample	Yes-216 **No-86 (24.7%)** I don't know-45
K7	The swab can be transported in a tube containing sterile saline	**Yes-119 (34.2%)** No-142 I don't know-86
K8	The temperature during transport of specimen should be 4 ºC	**Yes-201 (57.9%)** No-37 I don't know-109
K9	Induction of sputum is recommended wherever possible	Yes-71 **No-200 (57.6%)** I don't know-76
K10	Confirmed/suspected COVID-19 specimens to be labelled as UN2814 Category A, Infectious substance	Yes-149 **No-19 (5.4%)** I don't know-179
K11	Real-time reverse transcription (rRT-PCR) assay is the confirmatory diagnostic test done in a BSL-2 setup	**Yes-277 (79.8%)** No-21 I don't know-49
K12	If a specimen is positive for all three genes namely E-Sarbeco, RdRP and RNase P then it is reported as COVID-19 positive	**Yes-145 (41.7%)** No - 38 I don't know-164
K13	Being the internal control of the test, a negative status of RNase P gene mandates repeat rRT-PCR of the same specimen	**Yes-119 (34.2%)** No-42 I don't know-186
K14	All negative samples need to be discarded within 7 days	**Yes-160 (46.1%)** No-32 I don't know-155
K15	The biomedical waste (BMW) generated while processing samples for diagnosis of COVID-19 cases may be discarded like any other BMW	Yes-70 **No-224 (64.5%)** I don't know-53

*Correct responses in bold format with percentage in parenthesis. Abbreviations: COVID-19, coronavirus disease-2019; PPE, personal protective equipment

Of all participants, 76.3% were aware of the preference of nasopharyngeal swab as the preferred specimen over oropharyngeal swab. However, only 24.7% of all participants correctly stated that the sample should not be collected using a cotton swab while just 34.2% knew that sterile saline can be used for transporting the sample. Multivariate logistic regression analysis showed that those who were indirectly involved in the laboratory diagnosis of COVID-19 were more likely to get a high (OR: 4.713; 95% CI: 1.591–13.961; $P < 0.01$) or average (OR: 2.591; 95% CI: 1.106–6.070; $P < 0.05$) knowledge score than those who were not involved [Table 3]. Also, those with government websites as the major source of information were more likely to get an average score (OR: 6.184; 95% CI: 1.185–32.286; $P < 0.05$) than those having CDC or WHO websites as their major source of information.

Assessment of attitude

Participants were asked 14 questions to assess their attitude [Figure 1]. About two-thirds of all HCPs (66.3%) felt that the testing rate for detection of COVID-19 cases in the country is unsatisfactory and hence more than half (57.9%) were of the view that production of new test kits for detection of COVID-19 cases should be encouraged. Most (73.2%) HCPs felt that point-of-care-tests should be made available at the earliest. Majority of HCPs (67.4%) were fearful of getting infected at work due to laboratory delays in releasing test results. More than half of HCPs (55.6%) felt that the testing guidelines should be relaxed for asymptomatic HCPs and almost all (95.7%) felt that more funds should be allocated for production of personal protective equipment (PPE) and COVID-19 testing kits at the earliest. Maximum participants (90.5%) believed that more training programs targeted to sample collection, transport, and testing of suspected COVID-19 cases for all HCWs should be organized.

Table 3: Multinomial logistic regression analyses predicting knowledge scores with 'low score' as the reference category

Odds ratios of higher knowledge score with demographic characteristics (*n*=347)

Variables[a]	High score		Average score	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Place of work				
Tier 1 city vs others	2.082 (0.755-5.737)	1.639 (0.505-5.324)	1.327 (0.680-2.592)	1.095 (0.485-2.470)
Gender				
Female vs male	1.339 (0.582-3.077)	1.150 (0.462-2.863)	1.085 (0.587-2.007)	0.947 (0.475-1.887)
Age (years)				
<30	0.800 (0.110-5.819)	0.849 (0.073-9.922)	0.752 (0.199-2.844)	0.993 (0.171-5.773)
30-50	1.409 (0.220-9.008)	1.184 (0.151-9.272)	0.671 (0.189-2.382)	0.614 (0.147-2.575)
>50	Referent	Referent	Referent	Referent
Profession				
Doctor	Referent	Referent	Referent	Referent
Medical technologist	0.810 (0.226-2.903)	0.742 (0.182-3.029)	0.761 (0.293-1.981)	0.768 (0.263-2.240)
Nursing officer	0.971 (0.058-16.163)	0.602 (0.033-11.055)	1.522 (0.187-12.404)	1.254 (0.141-11.156)
Student/trainee	0.000	0.000	0.362 (0.138-0.954)*	0.296 (0.051-1.729)
Scientist	0.000	0.000	0.338 (0.030-3.834)	0.229 (0.017-3.124)
Duration of experience (years)				
<1	0.176 (0.020-1.578)	1.340 (0.072-25.116)	0.750 (0.284-1.978)	1.497 (0.209-10.724)
1-5	1.460 (0.523-4.075)	1.804 (0.463-7.030)	1.266 (0.570-2.812)	1.224 (0.406-3.693)
5-10	1.029 (0.358-2.957)	0.913 (0.287-2.907)	1.503 (0.696-3.247)	1.351 (0.572-3.189)
>10	Referent	Referent	Referent	Referent
Presence of diagnostic facility in hospital				
Yes vs no	1.173 (0.458-3.007)	0.909 (0.294-2.810)	1.153 (0.586-2.271)	1.163 (0.519-2.608)
Involvement in laboratory diagnosis of COVID-19				
Direct	2.308 (0.653-8.157)	1.536 (0.335-7.046)	1.711 (0.703-4.162)	0.944 (0.301-2.960)
Indirect	6.581 (2.413-17.949)‡	4.713 (1.591-13.961)†	3.445 (1.579-7.516)†	2.591 (1.106-6.070)*
Not involved	Referent	Referent	Referent	Referent
Working in lab				
Yes vs no	1.250 (0.076-20.614)	1.424 (0.068-29.705)	3.571 (0.465-27.458)	4.294 (0.441-41.808)
Major information source				
CDC or WHO website	Referent	Referent	Referent	Referent
Government website	5.000 (0.388-64.387)	4.024 (0.274-59.089)	6.200 (1.331-28.876)*	6.184 (1.185-32.286)*
Scientific articles	4.400 (0.418-46.261)	3.610 (0.292-44.606)	2.320 (0.608-8.858)	2.495 (0.565-11.018)
Workshop/training	2.118 (0.205-21.885)	1.828 (0.161-20.726)	1.176 (0.326-4.246)	1.105 (0.285-4.283)
Social media	3.000 (0.211-42.624)	2.541 (0.154-41.947)	1.800 (0.368-8.800)	1.376 (0.253-7.479)
Newspaper	4.000 (0.388-41.228)	2.924 (0.243-35.223)	1.867 (0.500-6.963)	1.740 (0.403-7.512)

The reference category is: low score; level of significance: *$P<0.05$, †$P<0.01$, ‡$P<0.001$. Abbreviations: COVID-19, coronavirus disease-2019; CDC, Centers for Disease Control and Prevention

S.No	Statements
A1	The testing rate of the country for the detection of COVID-19 cases is unsatisfactory
A2	Management of the COVID-19 patients is hugely dependent on laboratory
A3	Laboratory personnel are at higher risk of getting infected than their fellow clinicians
A4	Testing guidelines should be relaxed for asymptomatic healthcare professionals
A5	There is a delay in reporting results of the tests in the laboratories for COVID-19 cases
A6	The delay in test results adds fear to my mind of getting infected while at work
A7	Test results are more reliable if performed in an accredited laboratory
A8	Quality of sample sent to the laboratory influences the test results
A9	Blood-based antibody detection tests for COVID-19 are less reliable than molecular tests
A10	More training programs should be organised for all HCPs, related to sample collection, transport and testing of suspected COVID-19 cases
A11	More budget should be allocated by the government for PPEs and testing kits at the earliest
A12	POCT should be available for screening suspected COVID-19 patients
A13	Production of new diagnostic kits for detection of COVID-19 cases should be encouraged
A14	The documents released on laboratory diagnosis of COVID-19 by CDC, WHO, ICMR and local government bodies are easy to understand

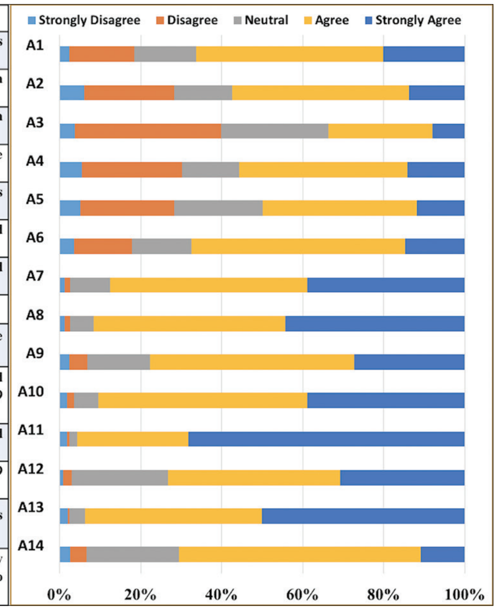

Figure 1: Attitude of HCPs on laboratory diagnosis of COVID-19

Table 4: Participants' response for practice towards laboratory diagnosis of COVID-19

S. No	Statements	Answered 'Yes' [*n* (%)]
P1	I have attended/organized workshop(s) or training program(s) on sample collection, transport and testing of suspected COVID-19 cases at my workplace	91 (26.2)
P2	I have consulted national/international guidelines to answer diagnosis-related queries of friends/relatives/patients	252 (72.6)
P3	I regularly post information related to COVID-19 on social media to create awareness	38 (11.0)
P4	I have discussed about COVID-19 diagnostic modalities with colleagues involved in the laboratory diagnosis to clear my doubts	168 (48.4)
P5	I have gone through online resources/webinars/YouTube videos to learn more about the detection of COVID-19 cases	175 (50.4)
P6	We have a separate bin in our workplace for discarding biomedical waste of suspected patients with COVID-19.	195 (56.2)

COVID-19, coronavirus disease-2019

Assessment of practice

Practices of HCPs were assessed using six questions [Table 4]. The mean practice score was 2.7 ± 1.6. Only 31.7% participants had a good practice score (>3). The mean practice scores were significantly different among HCPs of opposite sexes, HCPs with different professions and HCPs with different sources of information as major sources. They were also significantly different among HCPs with direct, indirect or no involvement in the laboratory diagnosis of COVID-19 [Table 1]. A little less than half of the participants (48.4%) had a discussion regarding details of laboratory diagnosis of COVID-19 with colleagues in the laboratory. Only half (50.4%) had explored and seen online videos to learn about the detection of COVID-19 cases [Table 4].

Those HCPs with direct or indirect involvement in the laboratory diagnosis of COVID-19 were more likely to get a good practice score (direct - OR: 6.272, 95% CI: 2.590–15.190, $P < 0.001$; indirect - OR: 2.346, 95% CI: 1.264-4.352, $P < 0.01$) than those with no involvement [Table 5]. HCPs working in the diagnostic laboratory for COVID-19 were more likely to have good practice score (OR: 5.488, 95% CI: 1.361–22.125; $P < 0.01$) in comparison to those who were not. Moreover, those who had attended training workshops were 4.6 times (OR: 4.639, 95% CI: 1.561–13.788; $P < 0.01$) more likely to have a good practice score than those having CDC or WHO websites as their major source of information.

Discussion

COVID-19 has had ravaging effects since its earliest detection in December 2019. This study was conducted amidst the evolving COVID-19 crisis in India. Most HCPs achieved an average knowledge score in our study. The medical technologists had the highest knowledge scores, followed by the doctors. The reason for this could be that almost half of the doctors did not have any involvement in the laboratory diagnosis of COVID-19. The motivation to gain knowledge is usually affected by the need. Quite likely, medical technologists actively acquired knowledge using various resources in order to perform their task more accurately and also to safeguard

Table 5: Binomial logistic regression analyses predicting practice scores with 'suboptimal scores" as the reference category

Odds ratios of higher practice score with demographic characteristics (*n*=347)		
Variables	**Odd ratios**	
	Crude (95% CI)	**Adjusted (95% CI)**
City of work		
Tier 1 city vs others	1.409 (0.813-2.443)	1.471 (0.739-2.929)
Gender		
Female vs male	0.666 (0.417-1.066)	0.577 (0.332-1.003)
Age (in years)		
<30	1.545 (0.594-4.019)	1.283 (0.337-4.886)
30-50	1.146 (0.459-2.857)	0.672 (0.212-2.133)
>50	Referent	Referent
Profession		
Doctor	Referent	Referent
Medical technologist	1.556 (0.778-3.112)	1.501 (0.635-3.550)
Nursing officer	0.214 (0.027-1.698)	0.207 (0.024-1.786)
Student/trainee	0.629 (0.225-1.762)	1.599 (0.334-7.644)
Scientist	0.000	0.000
Duration of experience (in years)		
<1	0.581 (0.221-1.530)	0.320 (0.067-1.534)
1-5	1.536 (0.863-2.736)	1.528 (0.0671-3.480)
5-10	1.123 (0.639-1.974)	1.015 (0.488-2.107)
>10	Referent	Referent
Presence of diagnostic facility in hospital		
Yes vs no	1.275 (0.745-2.181)	0.760 (0.383-1.510)
Involvement in laboratory diagnosis of COVID-19		
Direct	9.040 (4.482-18.233)‡	6.272 (2.590-15.190)‡
Indirect	2.560 (1.488-4.403)†	2.346 (1.264-4.352)†
Not involved	Referent	Referent
Working in lab		
Yes vs no	13.477 (3.837-47.334)	5.488 (1.361-22.125)*
Major information source		
CDC or WHO website	Referent	Referent
Government website	1.145 (0.592-2.213)	1.734 (0.807-3.725)
Scientific articles	0.722 (0.371-1.406)	1.121 (0.512-2.454)
Workshop/training	2.238 (0.899-5.571)	4.639 (1.561-13.788)†
Social media	0.363 (0.171-0.769)†	0.707 (0.298-1.678)
Newspaper	0.271 (0.057-1.284)	0.270 (0.031-2.383)

Level of significance: **P*<0.05, †*P*<0.01, ‡*P*<0.001. COVID-19, coronavirus disease-2019; CDC, Centers for Disease Control and Prevention

themselves from contracting infection due to improper handling of the received samples.

Most participants were aware that nasopharyngeal swab is preferable over oropharyngeal swab for sample collection but were misinformed about the details of swab, transportation medium and specimen labeling. CDC recommends the use of only synthetic fiber swabs with plastic or wire shafts and placing them immediately into a sterile transport tube containing 2–3 mL of either viral transport medium (VTM), Amies transport medium or sterile saline. Cotton swabs or swabs with wooden shafts may contain substances that inactivate some viruses and inhibit PCR testing.[3] Our study highlights the lack of knowledge amongst HCPs on the same. Majority of HCPs knew that the detection of unique sequences of viral RNA by RT-PCR is the gold standard for the diagnosis of COVID-19 but less than half were cognizant of the genes being tested, the basis of reporting the findings, and importance of knowing the validity of the test. This is comprehensible as most of the respondents were not working in the diagnostic laboratory and hence would not have felt the need to know the finer details of RT-PCR. It is encouraging that most HCPs were aware that the biomedical waste (BMW) generated while processing samples for diagnosis of COVID-19 cases should not be discarded like any other BMW, but less than half of all HCPs knew that even negative samples need to be discarded within 7 days.[10,11] Indian Council of Medical Research (ICMR) has been formulating and releasing guidelines on various aspects of laboratory diagnosis of COVID-19.[10] Obtaining information from these guidelines was found to be an independent predictor for achieving an average knowledge score in our study. It was heartening to note that about two-third of the HCPs claimed WHO or CDC website, government website or other scientific articles to be their major source of information while only one-fifth had social media as their major information source.

In general, more than 70% of all medical decisions are based on results from the medical laboratory.[14] And for the same, a 'proper representative specimen' must be sent to the laboratory for the diagnosis, especially for any infectious disease. A specimen if not collected accurately, may lead to false negative test results, further leading to delay in disease control and treatment. In our study, most participants agreed that the quality of samples received in laboratory influences the test results. About two-thirds of HCPs expressed fear of getting infected while at work due to laboratory delays in releasing test results and hence felt point-of-care testing for diagnosing COVID-19 should be made available at the earliest. Participants also felt that there is a need to increase the budget for production and acquisition of PPE and testing kits. Most of them knew that one needs to use PPE while processing the laboratory specimens. CDC has recommended the use of PPE that includes an N95 or higher-level respirator, eye protection, gloves, and a gown during specimen collection and processing.[3]

Most HCPs had a suboptimal practice score in our study. As anticipated, the medical technologists had significantly higher practice score in contrast to other HCPs who had relatively lesser practice score as nearly half of other HCPs were not involved in the laboratory diagnosis of COVID-19 at all. It was concerning to find out that a large proportion of the study population had not attended or organized any workshop or training program on laboratory diagnosis of COVID-19, though most were working in a hospital set up with facilities for diagnosing COVID-19. However, they showed a strong willingness to participate in such training programs.

We believe that the information on laboratory diagnosis of COVID-19 is as important as the information on prevention and treatment.[15] It is critical that HCPs including primary care physicians, considering their pivotal role in a pandemic situation, stay updated and well informed in order to disseminate correct information to the public in this testing time.[16] Our study highlights that although the HCPs understood the importance of sample collection and correct labelling, they lacked the current knowledge about the same.

The study has some limitations. Firstly, we self-formulated the questionnaire from the available WHO, CDC and ICMR guidelines as no standardized tool or previously used questionnaire was available for assessment of KAP regarding laboratory diagnosis of COVID-19. Secondly, the inherent methodological limitations of self-reported online survey include recall bias and social desirability bias, which may have affected the response of the participants and hence the results.[17] Thirdly, the study sampling was limited to the network of the researchers and was over-represented by doctors. Fourthly, COVID-19 testing in India has undergone paradigm changes in terms of testing strategies since the evolution of COVID-19 in the country. More studies with improved representation in the current situation are hence warranted.

Conclusions

In this exigency, timely dissemination of correct information is a necessity. The HCPs in our study achieved an average knowledge score but a poor practice score for the laboratory diagnosis of COVID-19. Nonetheless, they were willing to learn more through workshops, training and scientific journals. Attention towards expanding the knowledge on sample collection, transport and processing amongst HCPs could improve the related practices.

Ethical approval

The study was executed after the approval of the Institute Ethical Committee (IEC-312/27.4.2020).

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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