Screening COVID-19 Patients Using Safe Practice Score System in Non-COVID Radiology Departments

Kapoor Atul*, Kapur Aprajita, Mahajan Goldaa

Department of Radiology, Advanced Diagnostics and Institute of Imaging, Amritsar, Punjab, India

Abstract

Background: A prospective study was designed to evaluate the role of safe practice score system (SPSS) for targeted screening of patients in the non-COVID radiology department with the objective to (a) determine the incidence of COVID-19 in patients visiting non-COVID facilities, (b) to determine the sensitivity and specificity with predictive value of SPSS system to identify high-risk COVID patients undergoing ultrasound and echocardiographic examinations, (c) determination of relative risk (RR) estimation for health-care staff and other visiting patients and attendants, and (d) overall impact of the use of SPSS in the prevention of spread of the disease in the society. **Methods:** The study comprised a cohort of 688 patients who initially presented as non-COVID patients for ultrasound and echocardiography tests to a non-COVID health-care facility. Patients were divided into low-, moderate-, and high-risk COVID-19 probability groups based on SPSS screening scores of 0–3, 4–6, and more than 6, respectively. All high-risk patients with SPSS of more than 6 were advised real-time polymerase chain reaction (RT-PCR) or plain high-resolution computed tomography chest for the presence of COVID-19 before the diagnostic test could be done and all results were analyzed statistically. **Results:** Four hundred and forty-four low-risk patients had a median score of 3, and all underwent their radiological examinations. One hundred and forty patients were in the moderate-risk group and had a median score of 5. Thirty-six patients had a score of 6, out of which 12 patients were upgraded to score 6. One hundred and four patients were in the high-risk category group. Out of these, 20 patients were screened as RT-PCR negative and got their ultrasound examinations. The sensitivity and specificity of SPSS in categorizing patients into low and high risk were 100% and 95%, respectively, with false positive and negative of 4% and 0% with a positive and negative predictive value of 77% and 100%, respectively. The use of SPSS reduced the RR ratio for health-care workers and other staff from 7.9 to 2.6 ($P = 0.001$). The overall incidence of COVID-19 disease in patients visiting non-COVID hospitals was 12% during this time period. Screening and detection by the use of SPSS had a positive epidemiological impact and saved 33,000 people from getting infected when calculated by the susceptible-exposed-infectious-recovered (SEIR) pandemic model in this period of 90 days. **Conclusion:** SPSS categorized patients in low-, moderate-, and high-risk pretest COVID-19 probability categories accurately with good sensitivity and specificity and was useful in preventing the spread of disease with reduced RR to 2.6 for medical staff and other hospital patients and also helped to contain spread in the society.

Keywords: COVID-19, corona virus pandemic,Ultrasound, sonography, Echocardiography

INTRODUCTION

There have been a lot of guidelines on algorithms for triage and referral for COVID-19 patients in designated COVID hospitals[1] with guidelines in many countries to stop all elective medical examinations and treatments. Now, since health care is opening up globally, it is observed that more and more health-care workers are getting infected with COVID-19. Zabarsky et al.[2] showed that in their facility, 25% of workers infected with COVID-19 had a high-risk exposure than normal infected patients. This was due to a lack of compliance of safety norms, lapses, and lack of screening in non-COVID facilities. One of the primary goals of containing an pandemic is preventing its spread for which use of adequate personal protective equipment (PPE), reduction in work overload and increased diagnostic testing/ screening is recommended.[3-5]

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Address for correspondence: Dr. Kapoor Atul,
Department of Radiology, Advanced Diagnostics and Institute of Imaging,
17/8 Kennedy Avenue Amritsar - 143 001, Punjab, India.
E-mail: masatulak@aim.com

Early screening guidelines given by the Radiological Society of North America[6] comprised screening at the front desk with questionnaires about recent travel, contact, or fever and cough may not be enough now as there is community spread in many regions. There are also limitations in the resources to do rapid antigen/real-time polymerase chain reaction (RT-PCR) test on every incoming patient. Therefore, there cannot be a single solution to address this global challenge as situations and resources vary. Hence, there is an urgent need to have a more proactive screening program using available resources to triage patients for the probability of COVID-19 disease and to isolate them from others.[7] This study was designed to evaluate a rapid, cheap, and simple scoring system – screening safe practice score system (SPSS) at our institution to determine its performance in triaging patients presenting to a non-COVID health-care imaging facility.

MATERIALS AND METHODS

During the pandemic of COVID-19 following a lockdown period of 50 days in our country, resumption of essential imaging services was started for both outdoor and indoor patients in a tertiary imaging facility. A SPSS was formulated as a preregistration active screening measure for patients coming for ultrasound and echocardiography examinations. As per the WHO guidelines, all patients with nonemergent examinations were advised to postpone the examinations.[1] Informed consent was taken from all 688 patients who were screened in a period of 85 days using this method. The study was approved by the institutional ethics review board (AD_IRB_3/20). SPSS comprised the scoring of four parameters: history taking, presence of comorbid conditions, Spo2 level, and plain skiagram of the chest/point-of-care chest ultrasound in case of pregnant patients [Figure 1]. Observations were graded on a score of 1–3 for those who were without oxygen support on room air and on a score of 4–6 on those on oxygen support. The examinations were done taking all precautions of social distancing, using PPE and necessary sanitization methods including cleaning of equipment and patient bed after every examination and curtailing of visitors accompanying patients into the examination room. Plain skiagrams of the chest were done on a portable radiography system.

Patients were classified into three categories of pretest COVID-19 probability based on SPSS scores: low-risk COVID-19 (SPSS 0–3), moderate risk (SPSS 4–6), and high risk (SPSS 7 and above). All patients of moderate risk with a score of 6 also underwent complete blood count and C-reactive protein (CRP) levels. A score of 1 each was added to SPSS score if CRP was raised or if there was lymphopenia with a count less than 20 and an upgraded SPSS score was computed. Any patient with SPSS more than 6 was advised either RT-PCR test or plain high-resolution computed tomography (HRCT) of the chest before being taken up for ultrasound or echocardiography. Follow-up rapid antigen test or RT-PCR was also advised on follow-up of all patients in respective clinical wards and clinics as a gold standard of diagnosis of COVID-19.

Statistical analysis was done using Analyze-IT (Leeds, UK) for the following: (a) incidence of COVID-19 in a non-COVID health-care facility in the pandemic of COVID-19; (b) sensitivity and specificity with predictive value of SPSS system to screen high-risk COVID patients undergoing ultrasound and echocardiography; (c) determination of relative risk (RR) estimation of health-care staff, patients, and attendants; and (d) overall impact of the use of SPSS on the society in the prevention of spread of the pandemic using susceptible-exposed-infectious-recovered (SEIR) pandemic model.[8] This model describes the dynamics of the COVID-19 disease process based on its epidemiological characteristics, clinical progression and interventional measures used to contain the disease. The model is parameterized by the data obtained from confirmed and suspected cases of COVID-19 reported. Parameters of population under threat, incubation period, detection, and reproductive period of virus (R0) are used.

R0 for use in this study was obtained from national epidemiology data during this period of time for this state and was 1.6 based on data supplied by COV-IND-19 Study Group, School of Public health, University of Michigan, USA.

RESULTS

A total of 688 patients were screened using SPSS method in a period of 85 days. There were 425 males and 263 females with a

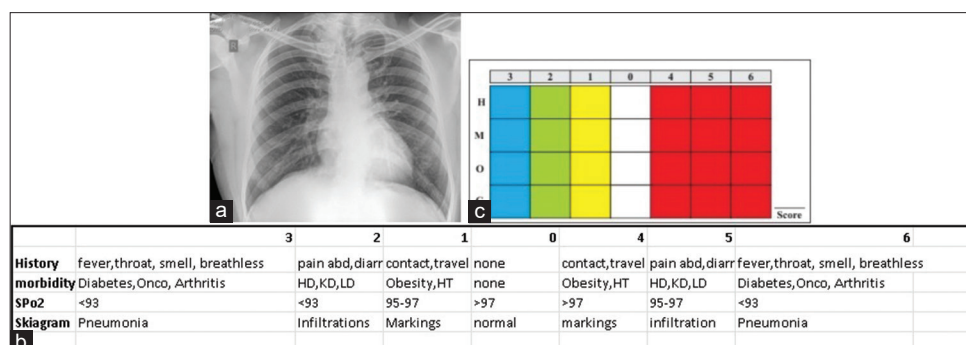|	3	2	1	0	4	5	6
History	fever, throat, smell, breathless	pain abd, diarr	contact, travel	none	contact, travel	pain abd, diarr	fever, throat, smell, breathless	
morbidity	Diabetes, Onco, Arthritis	HD, KD, LD	Obesity, HT	none	Obesity, HT	HD, KD, LD	Diabetes, Onco, Arthritis	
SPo2	<93	<93	95-97	>97	>97	95-97	<93	
Skiagram	Pneumonia	Infiltrations	Markings	normal	markings	infiltration	Pneumonia	

Figure 1: (a) Plain skiagram chest. (b) Parameters for evaluation of safe practice score system. (c) Color chart depiction of safe practice score system

mean age of 58 years with patient demographics [Table 1]. The most common presenting symptoms were pain abdomen (38%), fever (22%), breathlessness (13%), diarrhea (6%), and loss of smell (3%). One hundred and twenty patients comprised echocardiographic examinations, whereas the rest were routine ultrasound abdominal and antenatal evaluations.

Four hundred and forty-four patients were in low COVID risk category and had a median score of 3 [Figure 1 and Table 2], and all completed their radiological examinations. One hundred and forty patients were categorized as moderate-risk patients with a median score of 5 [Figure 2]. There were 36 patients in this group who had a score of 6 and also got blood lymphocyte count and/or CRP levels, after which their score was reviewed. Twelve patients whose score was unchanged were cleared for imaging, whereas 24 patients' score was upgraded to 6 and above. Their examinations were postponed and advised a prior RT-PCR or HRCT examination.

One hundred and four high-risk category patients were detected by SPSS and had a median score of 10 with 30 on oxygen support. Only 20 patients who underwent imaging examinations after their plain HRCT were found to be normal, and in the rest 84 patients, examinations were postponed [Figures 3 and 4].

A total of 108 patients (84 from the high-risk group and 24 from the moderate-risk group) were labeled as suspicious for COVID-19. Fifty-six were detected to be having typical COVID-19 like radiological findings on plain HRCT, whereas 27 were RT-PCR positive. Twenty-five patients refused to undergo RT-PCR or HRCT and were sent back to the referring clinicians; they were excluded for statistical analysis purposes from the study. Overall, 663/688 patients underwent rapid antigen test and/or RT-PCR tests as a gold standard for diagnosis. None of the screened 444 patients of the low-risk group had a positive RT-PCR test. Fifteen patients in the moderate-risk group had RT-PCR/rapid antigen positive, whereas 125 patients were true negative and nine patients were false positive by SPSS in this group. Out of 104 patients of the high-risk group, 68 were true positive for COVID-19 by RT-PCR, whereas 25 patients refused to undergo further tests.

SPSS system showed an incidence rate of 12% (84/688) of COVID-19 disease during this period in patients visiting non-COVID health-care facilities for symptoms other than influenza-like illness. SPSS had a sensitivity and specificity of 100% and 95% to detect the pretest probability of COVID-19 with a positive and negative predictive value of 77% and 100%, respectively, in patients coming to a non-COVID health-care facility [Table 3]. With the use of SPSS, the RR ratio for health-care staff and other patients was reduced by three times from 7.9 to 2.6 ($P = 0.0001$). SEIR epidemic risk calculator showed that the SPSS method helped to prevent infection in 22,000 people by timely detection and isolation [Figure 5]. It reduced 5000 hospitalizations at a rate of 6.94% and reduced mortality to 2.94%.
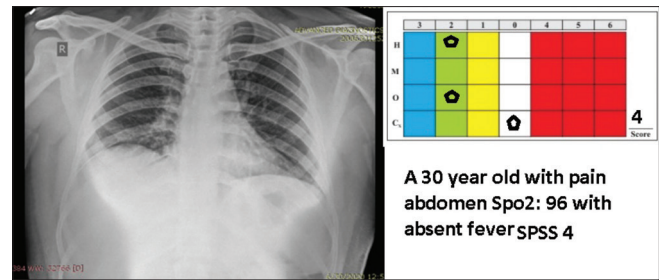

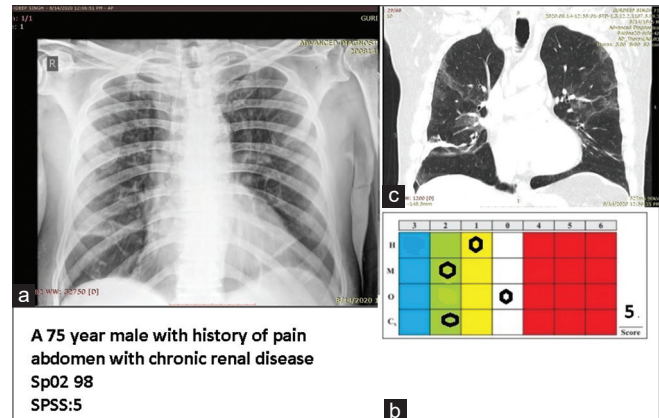**Figure 2:** A 30-year-old with pain abdomen with safe practice score system of 4

Figure 3: A 75-year-old male with chronic renal disease and pain abdomen. (a) Plain skiagram showing infiltrate in the right lower zone. (b) Safe practice score system of 5. (c) Plain high-resolution computed tomography showing multiple ground-glass opacities of COVID-19 disease.
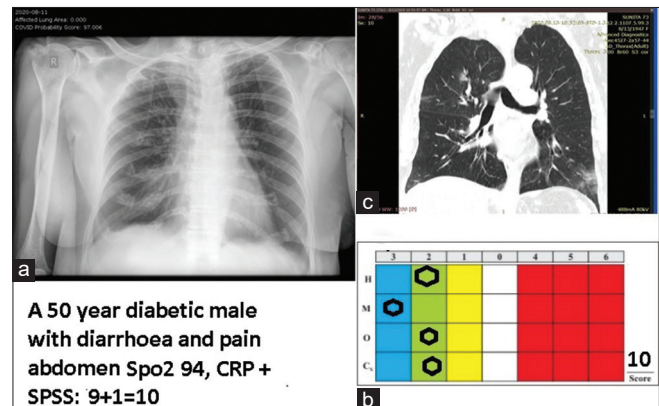

Figure 4: A 50-year-old diabetic with diarrhea. (a) Plain skiagram chest with left basal infiltrate. (b) Safe practice score system 10. (c) High-resolution computed tomography showing multiple ground-glass opacities.

Discussion

Word triage means successfully sorting out and classifying patients according to the priority and disease.[9] This study shows that with the use of SPSS, we could successfully triage patients into low-, moderate-, and high-risk COVID-19 probability categories. The study shows that during the

ongoing pandemic, there were 12% COVID-19-infected patients visiting COVID hospitals, which was a significant number to increase the spread of disease. Out of them, majority of these patients had nonspecific symptoms such as pain abdomen (38%), diarrhea, and breathlessness and
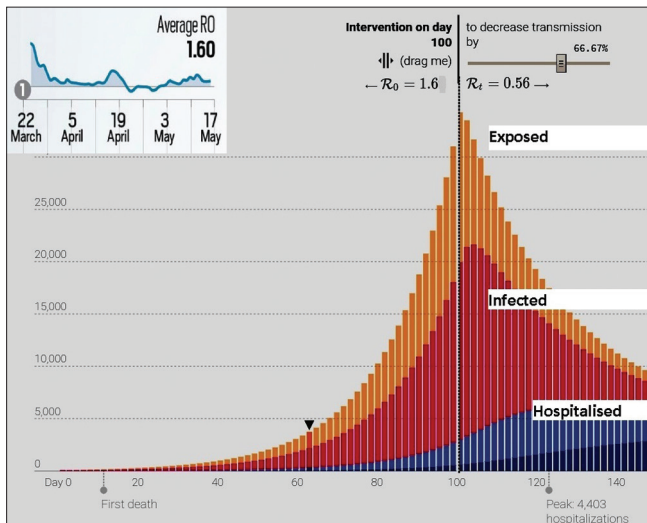

Figure 5: Histogram plot showing the impact of safe practice score system on society in a 90-day period with inset of R0 graph in this time period

thus not only would escape the early detection of COVID-19 disease but also were a risk for attending medical staff and attendants and to the society as a whole. In this study, it was seen that even a small number of patients who had more specific symptoms of COVID-19 like loss of smell can also present to non-COVID hospitals and it was important to triage such patients before they are taken up for radiological evaluation. The use of SPSS in this study triaged this small number as patients with moderate risk by upgraded SPSS score of more than 6 and all had their RT-PCR-positive tests before being examined. This highlights the need for increased alertness for symptoms and history taking by the sonographer before taking up the patient for a radiological evaluation and the use of SPSS successfully flags such patients before their radiological examination. SPSS had a maximum impact in moderate- and high-risk patient groups for the detection of COVID-19. During the pandemic, a robust preimaging screening measure which is quick, cheap, and easily performed is required with a high (100%) negative predictive value. Tacconelli[10] in their study also advocated a proactive screening protocol to screen and isolate such patients. SPSS is similar to the clinical Manchester Triage System which on the basis of history and signs classified patients into five categories of urgency requiring physician attention.[11] The current study shows that the SPSS system is quick and easy to perform and classifies patients into low-, medium-, and high-risk categories with 100% sensitivity and 95% specificity. It did not miss any COVID-19 patient in all the groups and thus prevented exposure in the medical staff and other hospital patients. Patients with high SPSS score of more than 7 had a 77% positive predictive value in predicting COVID-19 disease with high likelihood ratio of 24%. There were 4% of false-positive non-COVID patients in the study with SPSS of more than 7. These were non-COVID patients with other acute chest infections, acute pulmonary edema, and renal failure and had false high SPSS scores of more than 10. It was observed that these false-positive results had no impact on the primary objective of screening in this scenario which was the containment of cross infection among health workers, hospital visitors, and early identification of COVID-19 patients in a non-COVID health facility. The current study also shows that low SPSS score had a 100% negative predictive value for COVID probability risk in symptomatic patients as there were no false-negative patients

Table 1: Patient demographics

	Showing patient demographics (*n*-688)		
S.No	Parameters	Number	Percentage
1	Mean Age	58 years	
2	Sex		38
	Females	263	62
	Males	425	
3	Symptoms		
	Fever	151	22
	Breathlessness	89	13
	Cough	68	10
	Pain abdomen	261	38
	Diarrhoea	11	6
	Loss of smell	5	3
	Anuria	7	4
	Loss of appetite	103	15
	Feeling of unwell with body aches	178	26

*Pregnancy 72

Table 2: Classification based on SPSS

S.no	Parameters	Low risk category (SPSS0-3)	Moderate risk(SPSS 4-6)	High risk(SPSS>6)
1	Number of patiens	*n*=444	*n*=140	*n*=104
2	Scans postponed	none	24	84
3	Median SPSS	3	5	10
4	Upgraded SPSS	none	24	none
5	Covid RTP CR positive	none	7	20
6	Covid like CT findings	none	3	53

* 25 lost to follow up

Table 3: Test performance analysis of safe practice score system in high risk pretest probability

	Covid-19		
SPSS	Abnormal +	Normal -	Total
Abnormal +	83	24	107
Normal-	0	556	556
TOTAL	83	580	663

* 25 Patients excluded

Sample prevalence   0.125

		95%CI
Sensitivity-TP Proportion	1.000	0.957 to 1.000
Specificity-TN proportion	0.959	0.939 to 0.973
FP proportion	0.041	0.027 to0.061
FN proportion	0.000	0.000 to 0.043
Likelihood ratio(+)	24.17	
Likelihood ratio(-)	0.00	
At sample prevalence		
Correct classification	0.964	0.947 to 0.977
Misclassification	0.036	0.23 to 0.053
Positive predictive value	0.776	0.685 to 0.851
Negative predictive value	1	0.993 to 1.000

in SPSS 0–6 categories, thus fulfilling the primary objective of the study. This makes it an effective pretest screening procedure for labeled non-COVID symptomatic patients. The present study also shows that during the pandemic, tertiary hospitals or diagnostic facilities catering to non-COVID patients are at a risk of harboring COVID-19 patients with active disease – 12% in this study which is a high number – and carry the potential to infect others. Simple front desk screening of temperature and history taking alone may not be enough and a more robust protocol is required. In China, quick response teams were formed in accordance with the Chinese "Diagnosis and treatment guideline for novel coronavirus pneumonia (Trial version 6)[12]," where a routine blood test, chest radiography, quick screening of swab, or respiratory secretion was used in a suspected COVID patient.[12] Due to time constraints, lack of logistics, and availability of swab tests, it may not be possible to formulate such a response in every department. SPSS system is quite similar to the above screening guidelines and appears to be a two-stage system with the first stage triaging low- and moderate-risk patients from high risk with the latter undergoing the second stage of triage with RT-PCR or plain HRCT. Time delays for required diagnosis could be curtailed to minimum if plain HRCT is used in an emergency. Out of 108 patients who were identified as high-risk COVID probability by SPSS, 56 patients had COVID-19 radiology on HRCT in this study. HRCT also had an advantage in symptomatic patients due to higher sensitivity compared to RT-PCR alone.[13] Nonurgent (27/108) high-risk COVID probability patients had a positive RT-PCR in the present study. All these positive patients were shifted to COVID wards from their current health-care facilities, thus highlighting the usefulness of SPSS in not only early

diagnosis but also in the prevention of spread of the disease. It also alerted public health departments for contact tracing and isolation of contacts of these patients. Twenty-five patients who did not consent for further examinations were also quarantined for further investigations.

CONCLUSION

This study highlights the necessity for an institution-specific protocol for screening incoming patients during outbreak of a pandemic which will not only identify patients with COVID-19 but also protect the risk of cross infection among health workers. Current study shows that the RR ratio was reduced from 7.9 to 2.6 by the use of SPSS which helped to preserve medical resources for a long term fight against this pandemic. The use of SPSS also showed a significant bearing on the society as a whole as the results of this study when used on a SEIR pandemic model showed that detection of 83 patients among a non-COVID symptomatic patient cohort resulted in the prevention of infection in 33,000 patients in a population of 1.2 million over a period of 90 days which was significant. We are unaware of any other active quickly implantable screening program being used in a non-COVID hospital. The current study suggests that such models must be implemented as tools in the fight against this pandemic along with the use of RT-PCR test.

Conflicts of interest
There are no conflicts of interest.

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